DOCUMENT RESUME

ED 255 333 RC 015 077

TITLE	Thermal Standard for Small Rural Schools.
INSTITUTION	Alaska Univ., Fairbanks. Dept. of Mechanical Engineering.; Strandberg (J.S.) Consulting Engineering, Fairbanks, AK.
SPONS AGENCY	Alaska State Dept. of Transportation and Public Facilities, Anchorage.
REPORT NO	AK-RD-83-04
PUB DATE	83
NOTE	81p.
AVAILABLE FROM	State of Alaska, Dept. of Transportation and Public Facilities, Div. of Planning, Northern Region, 2301 Peger Road, Research Section, Fairbanks, AK 99701.
PUB TYPE	Guides - Non-Classroom Use (055)
EDRS PRICE	MF01/PC04 Plus Postage.
DESCRIPTORS	Air Conditioning; Alternative Energy Sources; *Educational Facilities Design; *Energy Conservation; Heating; Lighting Design; *Rural Schools; School Construction; *Small Schools; *State Standards; *Thermal Environment
IDENTIFIERS	*Alaska

ABSTRACT

The Standard's purpose is to provide design requirements that will improve energy utilization in new State of Alaska owned rural educational facilities ranging in size from 7,000 to 12,000 square feet. The Standard covers exterior envelopes and selection of heating, ventilating and air conditioning systems, service water systems, energy distribution systems, illumination systems, and other energy consuming equipment. The requirements are directed toward reducing the State of Alaska's annual energy consumption through ensuring adequate thermal resistance and low air leakage, designing and selecting effective systems and equipment, and prudently selecting fuel and energy sources. The Standard is flexible and provides designers with a coherent set of thermal guidelines that accommodate Alaska's widely varying environmental and economic conditions; designers are encouraged to use innovative approaches and techniques to achieve efficient energy utilization. The Standard imposes minimum requirements for thermal characteristics of various energy consuming systems in buildings and addresses the applicability of mechanical system types for rural Alaska by providing guidelines for level of complexity of heating system components. The Standard should be used in the design of new buildings and compliance with its requirements should be determinable in the preconstruction stage through design evaluation and analysis. (BRR)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
State of Alaska
Dept. of Transportation
and Public Facilities
Research Section
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.
☑ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

RC015077

THERMAL STANDARD FOR SMALL RURAL SCHOOLS

by

J. S. Strandberg Consulting Engineers

PO Box 319
Fairbanks, Alaska 99707

1983

Prepared for:

Department of Mechanical Engineering
University of Alaska
Fairbanks, Alaska 99701

TABLE OF CONTENTS

		PAGE #
1.0	**PURPOSE**	1
2.0	**SCOPE**	2
3.0	**DEFINITIONS**	3
4.0	**EXTERIOR ENVELOPE REQUIREMENTS**	4
	4.1 Scope	4
	4.2 General	4
	4.3 Envelope Criteria	7
	4.3.1 Heating	7
	4.3.1.1 Walls	7
	4.3.1.2 Roof/Ceiling	9
	4.3.1.3 Floors over Unheated Spaces	11
	4.3.2 Cooling Criteria	13
	4.3.3 Air Leakage	13
	4.3.3.1 General	13
	4.3.3.2 Windows	13
	4.3.3.3 Swinging and Overhead Doors	13
	4.3.3.4 Caulking and Sealants	14

TABLE OF CONTENTS

		PAGE #
5.0	**HEATING, VENTILATING AND AIR CONDITIONING SYSTEM**	15
	5.1 Scope	15
	5.2 General	15
	5.3 Calculation of Heating/Cooling Loads	15
	5.3.1 Procedures	15
	5.3.2 Design Parameters	15
	5.3.2.1 Outdoor Design Conditions	15
	5.3.2.2 Indoor Design Conditions	21
	5.3.2.3 Ventilation Standards	21
	5.3.2.4 Infiltration	21
	5.4 Allowable Systems Design Concepts	23
	5.4.1 Hydronic Based Systems	23
	5.4.2 Combined Heating/ Ventilation Systems	24
	5.4.3 System Applicability	24
	5.4.4 Use of Heat Recovery	24
	5.5 Controls Design Concepts	25
	5.5.1 Temperature Controls	25
	5.5.2 Humidity Control	25
	5.5.3 Zoning	25
	5.5.4 Controls Setback and Shutoff	26
	5.5.5 Ventilation Control Sequencing	26

TABLE OF CONTENTS

		PAGE #
	5.5.6 Use of Economizer Cycle	27
	5.5.7 Scheduling Outside Air Ventilation	27
	5.6 Transport Energy	27
	5.7 Piping Insulation	28
	5.7.1 Other Insulation Thicknesses	28
	5.8 Air Handling System Insulation	30
	5.9 Duct Construction	31
	5.10 Balancing	31
6.0	**HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) EQUIPMENT**	32
	Note: These items are included in companion sections of ASHRAE Standard 90A.	
7.0	**SERVICE WATER HEATING**	33
	Note: These items are included in companion sections of ASHRAE Standard 90A.	
8.0	**ENERGY DISTRIBUTION SYSTEMS**	34
9.0	**LIGHTING SYSTEMS**	35
	9.1 Purpose	35
	9.2 Scope	35
	9.3 General	35
	9.3.1 Exception	35

TABLE OF CONTENTS

		PAGE #
9.4	Design Procedure Using Watts Per Square Foot of Floor Areas	35
9.4.1	Interiors	35
9.4.2	Exteriors	36
9.4.3	Lighting Power Budget	36
9.4.4	Exceptions	36
9.5	Documentation	36
9.6	Lighting Switching	38
10.0	**ENERGY REQUIREMENTS FOR BUILDING DESIGN ON SYSTEMS ANALYSIS**	39
	Note: These items are included in companion sections of ASHRAE Standard 90-75.	
11.0	**REQUIREMENTS FOR BUILDINGS UTILIZING SOLAR, GEOTHERMAL, WIND OR OTHER NON-DEPLETING ENERGY SOURCES**	40
	Note: These items are included in companion sections of ASHRAE Standard 90-75.	
12.0	**REFERENCES**	41
APPENDIX A	Section 3 ASHRAE Standard 90A.	42
APPENDIX B	Sections 6 and 7 ASHRAE Standard 90A.	49
APPENDIX C	Sections 10 and 11 ASHRAE Standard 90-75.	61

LIST OF FIGURES

FIGURE #		PAGE #
1	Map of Alaska Showing Climate Zones	5

LIST OF TABLES

TABLE #		PAGE #
1	Composite Wall R-Value Requirements	8
2	Composite Roof R-Value Requirements	10
3	Composite Floor R-Value Requirements	12
4	Design Weather Data	16
5	Natural Ventilation Rate (AC/HR)	22
6	Minimum Pipe Insulation	29
7	Required R-Factors	30
8	Maximum Lighting Power Densities	37

1.0 PURPOSE

1.1 The purpose of the Standard is to provide design requirements that will improve energy utilization in new buildings.

1.2 The requirements of this Standard are directed toward the design of building envelopes to ensure adequate thermal resistance and low air leakage; toward the design and selection of mechanical, electrical, service water heating, and illumination systems and equipment; and toward the prudent selection of fuel and energy sources; all of which will result in reduction in the State of Alaska's annual energy consumption.

1.3 It is intended that the Standard be a flexible document providing designers a coherent set of thermal guidelines that accommodate the widely varying environmental and economic conditions present in the State today. Designers are encouraged to use innovative approaches and techniques to achieve efficient energy utilization. Sections 10 and 11 of the Standard provide for evaluation of alternative design solutions.

1.4 The Standard is in the format of a "Component Standard", that imposes minimum requirements for thermal characteristics of the various energy consuming systems in the building. The Standard addresses the applicability of mechanical system types for rural Alaska, by providing guidelines for level of complexity of heating system components.

1.5 It is intended that this Standard be used in the design of new buildings and that compliance with its requirements should be determinable in the preconstruction stage, by evaluation and analysis of the design.

2.0 SCOPE

2.1 This Standard sets forth requirements for the design of new State of Alaska owned buildings. The Standard covers exterior envelopes, and selection of HEATING, VENTILATING AND AIR-CONDITIONING (HVAC), service water systems, energy distribution systems, illumination systems and other energy consuming equipment. This Standard covers new State owned buildings that provide educational facilities in rural Alaska, and for buildings that range in size from 7,000 to 12,000 square feet.

3.0 DEFINITIONS

Terminology used in this Standard conforms to that used in the referenced ASHRAE Standard 90A (Reference 1). Section 3 DEFINITIONS from ASHRAE Standard 90A is included as Appendix A.

4.0 EXTERIOR ENVELOPE REQUIREMENTS

4.1 Scope:

The criteria of this section establish the minimum thermal requirements of the exterior envelope of new buildings. The equations, charts, and tables in this section are intended only for use in defining these criteria. In cases where a system analysis approach to building design is desired, the requirements of Appendix C apply.

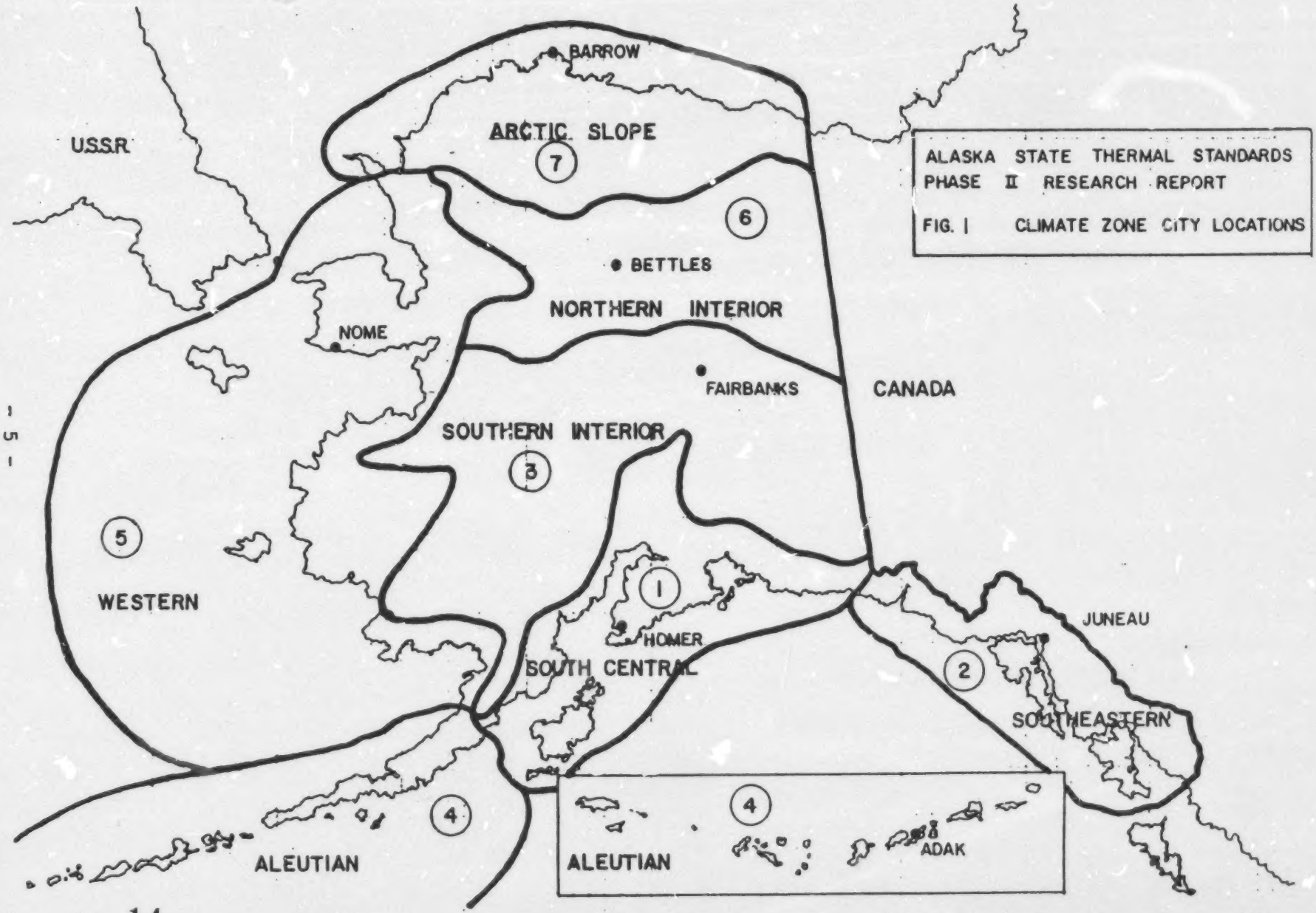
4.2 General:

4.2.1 The following sub-paragraphs provide minimum requirements for building envelope construction in the interest of energy conservation.

4.2.2 In addition to the criteria set forth in this section, the proposed design should consider energy conservation in determining the orientation of the building on its site; the geometric shape of the building; the building aspect ratio (ratio of length to width); the number of stories for a given floor area requirement; shading or reflections from adjacent structures, surrounding surfaces or vegetation; opportunities for natural ventilation; and wind direction and speed.

Discrete envelope requirements are set forth for seven climate zones of Alaska. These zones are presented on Figure 1.

4.2.2.1 To develop the exterior envelope requirements, the calculation procedures and information contained in Chapters 20-28 of the 1981 ASHRAE HANDBOOK & Product Directory, Fundamentals Volume (Reference 2), shall be used. Other available measured thermal performance data for envelope sections, either from laboratory or field data or from engineering analysis may be considered either in addition to, or in place of, the criteria set forth in this section providing equal and repeatable results can be proven. Specifically referenced herein is the following report: "Report Supplement: Thermal and Cost Analysis of Thermal Envelopes for a Small Rural School" (Reference 3).


ALASKA STATE THERMAL STANDARDS
PHASE II RESEARCH REPORT
FIG. 1 CLIMATE ZONE CITY LOCATIONS
BARROW
ARCTIC SLOPE
7
USSR
6
BETTLES
NORTHERN INTERIOR
NOME
FAIRBANKS
CANADA
SOUTHERN INTERIOR
3
5
WESTERN
1
HOMER
SOUTH CENTRAL
JUNEAU
2
SOUTHEASTERN
4
ALEUTIAN
4
ALEUTIAN
ADAK

4.2.2.2 The gross area of exterior walls measured on the exterior consists of all opaque wall areas (including foundation walls, between floor spandrels, peripheral edges of floors, etc.), window areas (including sash), and door areas, which enclose a heated and/or mechanically cooled space (including intersitial areas). The total window areas for the facility shall be no greater than 400 square feet based on architectural aesthetics, potential means of egress, and possible ventilation.

4.2.3 A roof assembly shall be considered as all components of the roof/ceiling envelope through which heat flows, thus creating a building transmission heat loss or gain, where such assembly is exposed to outdoor air and encloses a heated and/or mechanically cooled space.

4.2.3.1 The gross area of a roof assembly consists of the total interior surface of such assembly, including skylights exposed to the heated and/or mechanically cooled space.

4.2.3.2 Where return air ceiling plenums are employed the roof/ceiling assembly shall, for thermal transmittance purposes, not include the ceiling proper nor the plenum space as part of the assembly, and for gross area purposes be based upon the interior face of the upper plenum surface.

4.2.4 All buildings that are heated and/or mechanically cooled shall be constructed to provide the required thermal performance of the various components.

4.2.4.1 The stated R value of any one assembly, such as roof/ceiling, wall or floor, may be increased and the R value for other components decreased provided that the overall heat gain and/or loss for the entire building envelope does not exceed the total resulting from conformance to the stated R values.

4.2.4.2 The following dry bulb temperatures shall be used for calculations in this section:

	Indoor (Design Temperature)	Outdoor (Frequency Level Requirement)
Winter	70 degrees F	97 1/2%
Summer	78 degrees F	2 1/2%

4.2.5 A building designed to be both heated and/or cooled shall meet the more stringent of the heating or cooling requirements of the exterior envelope as provided in this section when requirements differ.

4.2.6 The design of buildings for energy conservation may increase the water vapor pressure differentials between the interior and exterior environments. Vapor retarders, air infiltration, and operating interior relative humidity should be considered to maintain the thermal and moisture integrity of the envelope.

4.3 Envelope Criteria:

4.3.1 Heating:

4.3.1.1 **Walls:** Any building that is heated and/or mechanically cooled shall have combined thermal resistance values (R values) for each envelope component greater than or equal to values shown in Table 1.

TABLE 1

COMPOSITE WALL R-VALUE REQUIREMENTS

Climate Region	Region Title	Required Minimum R-Value (Hr-sq.ft.-deg F/BTU)
1	South Central	15.8
2	South Eastern	20.8
3	Southern Interior	20.8
4	Aleutian	15.8
5	Western	20.8
6	Northern Interior	20.8
7	Barrow	15.3
7	North Slope	20.8

Note: Composite wall R-values include windows and doors.

The following equation is to be used for determining component R Factors for wall sections:

$$R = \frac{Ao}{(A/R)wall+(A/R)fenestration+(A/R)door} \qquad (1)$$

where

R = the average thermal resistance of the gross wall area, Hr-sq.ft.-deg.F/BTU.

Ao = the gross area of exterior walls, sq.ft.

Awall = opaque wall area, sq.ft.

Afenestration = window area (including sash), sq.ft.

Adoor = door area, square feet.

Rwall = the thermal resistance of all elements of the opaque wall area, Hr-sq.ft.-deg.F/BTU.

Rfenestration = the thermal resistance of the window area, Hr-sq.ft.-deg.F/BTU.

Rdoor = the thermal resistance of the door area, Hr-sq.ft.-deg.F/BTU.

Note: Where more than one type of wall, window and/or door is used, the A/R term for that exposure shall be expanded into its sub-elements, as:

(A/R)wall-1 + (A/R)wall-2 + (A/R)wall-3 + ...

4.3.1.2 **Roof/Ceiling.** Any building that is heated shall have a thermal resistance value (R value) for the gross area of the roof assembly greater than or equal to the value shown in Table 2. Values shall be selected for the climate region the proposed facility is located within.

TABLE 2

COMPOSITE ROOF R-VALUE REQUIREMENTS

Climate Region	Region Title	Required Minimum R-Value (Hr-sq.ft.-deg F/BTU)
1	South Central	23.5
2	South Eastern	42.0
3	Southern Interior	60.0
4	Aleutian	23.0
5	Western	42.0
6	Northern Interior	60.0
7	Barrow	42.0
7	North Slope	60.0

Equation 2 shall be used to determine acceptable combinations where the designer elects to use a concept different than listed under Table 2.

The following equation is to be used for determining average thermal resistance values for combinations of roofs and skylights:

$$R = \frac{Ao}{(A/R)roof + (A/R)skylight} \qquad (2)$$

where

R = the average thermal resistance of the gross roof/ceiling area, Hr-sq.ft.-deg.F/BTU.

Ao = the gross area of a roof/ceiling assembly, sq.ft.

Aroof = opaque roof/ceiling assembly, sq.ft.

Askylight = skylight area (including frame), sq.ft.

Rroof = the thermal resistance of all elements of the opaque roof/ceiling area, Hr-sq.ft.-deg F/BTU.

Rskylight = the thermal resistance of all skylight, Hr-sq.ft.-deg F/BTU.

Note: Where more than one type of roof/ceiling and/or skylight is used, the A/R terms for that exposure shall be expanded into its sub-elements, as:

$$R = \frac{Aroof1 + Aroof2 + Aroof3 + \ldots}{(A/R)roof1 + (A/R)roof2 + (A/R)roof3 + \ldots}$$

4.3.1.3 Floors over Unheated Spaces: The R value shall be greater than or equal to the values shown in Table 3. For floors of heated spaces over unheated spaces, including pile-supported floors.

TABLE 3

COMPOSITE FLOOR R-VALUE REQUIREMENTS

Climate Region	Region Title	Required Minimum R-Value (Hr-sq.ft.-Deg.F/BTU) Elevated Floor	Crawlspace
1	South Central	36	12.8
2	South Eastern	44	18.2
3	Southern Interior	44	18.2
4	Aleutian	25	7.4
5	Western	44	18.2
6	Northern Interior	44	18.2
7	Barrow	44	20.0
7	North Slope	44	20.0

For heated crawlspace foundations, R-values for wall insulation installed on exterior of perimeter foundation walls shall be greater than or equal to R-value in Table 3.

4.3.2 **Cooling Criteria:** Building envelope systems shall be constructed to prevent overheating through appropriate mechanical/natural ventilation schemes, and careful orientation of window areas. The use of mechanical cooling is prohibited, except in cases where use of such cooling can be shown to result in reduced energy consumption from that of a non-mechanically cooled design, in accordance with Appendix B of this Standard. Cooling requirements that arise from interior process equipment are excluded from this requirement.

4.3.3 **Air Leakage:**

4.3.3.1 **General:** The requirements of this section are limited to those locations separating exterior building ambient conditions from interior building conditioned air space and are not applicable to the separation of interior conditioned spaces from each other.

Compliance with the criteria for air leakage shall be determined by ANSI/ASTM E 283-73, Standard Method of Test for Rate of Air Leakage through Exterior Windows, Curtain Walls and Doors (Reference 4), at a pressure differential of 1.57 lb/sq.ft., which is equivalent to the effect of a 25mph wind.

4.3.3.2 **Windows:** Windows shall be designed to limit air leakage; the air infiltration rate shall not exceed 0.35 cu.ft./min per foot of sash crack. See Section 4.3.3.1.

4.3.3.3 **Swinging and Overhead Doors:** Swinging doors shall be used exclusively for personnel access. Doors shall be designed to limit air leakage. Fitting shall be maintained tight, with full face weather stripping.

Overhead doors shall be tight fitting along the top and sides and shall have full face weather stripping along the bottom.

There is currently no Standard for overhead access doors.

4.3.3.4 **Caulking and Sealants:** Exterior joints in the building envelope that are sources of air leakage such as around window and door frames, between wall cavities and window or door frames, between wall and foundation, between wall and roof, between wall panels, at penetrations or utility services through walls, floors and roofs, shall be caulked, gasketed, weatherstripped, or otherwise sealed. Provide sealing using good construction practices, that will not result in trapped moisture within envelope insulation.

Vapor Barriers: Install interior vapor barriers on the warm side of the wall section. Minimize penetrations in vapor barrier, and where penetrations must occur, such as around electrical boxes or duct penetrations, seal vapor barrier with caulking and/or tape.

Air Barriers: The use of air barriers in exterior envelopes is encouraged. Carefully seal around all windows and door frames, to provide a smooth unbroken barrier to the flow of air through envelope components.

5.0 HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS:

5.1 Scope:

This section covers determination of heating and cooling loads, design requirements, and control requirements for general comfort applications in new buildings where normally clothed people are engaged in sedentary or near-sedentary activities. Criteria are established for insulating systems and for duct construction.

5.2 General:

This section establishes HVAC system requirements for effective utilization of energy. System criteria developed from the requirements of this section may influence the type of controls furnished with the equipment selected in accordance with section 6. It is recommended that the HVAC system selection process include an annual energy use evaluation.

5.3 Calculation of Heating/Cooling Loads:

5.3.1 Procedures:

Heating and cooling design loads for the purpose of sizing systems shall be determined in accordance with one of the procedures described in the ASHRAE HANDBOOK 1981 Fundamentals Volume, Chapters 25 and 26 (Reference 2), or an equivalent computation procedure.

The procedures in Section 4 of this Standard are used for determining the thermal design of the exterior envelope and are not considered equivalent for the purpose of sizing.

The design parameters in Section 5.3.2 shall apply for all computational methods.

5.3.2 Design Parameters:

The following design parameters shall be used for system design load calculations for general comfort applications.

5.3.2.1 **Outdoor Design Conditions:** Winter and summer outdoor design conditions shall be selected for listed locations in Table 4. Adjustments may be made to reflect local climates which differ from the temperatures listed in the Table 4,

TABLE #4

DESIGN WEATHER DATA

Station	Winter Design Dry Bulb Temperature	Heating Degree Days	Summer Design Dry Bulb Temperature	Location *** N. Lat.	W. Long.	Pvlg. Wind (Dir)	Mean Speed (Knots)
Adak	23	8825	59	51-53	176-39	W	7
Anchorage IAP	-18	10911	68	61-10	150-01	SE	3
Aniak	-39	13412	71	61-35	159-32	E	3
Annette	17	7053	70	55-02	131-34	NE	12
Anvil Mt.	-27	14555	60	64-34	165-22	N	8
Attu	22	8339	57	52-30	173E-10	NW	12
Barrow	-41	20265	53	71-18	156-47	SW	8
Barter Island	-41	19994	52	70-08	143-38	SW	7
Bear Creek	-35	13861	73	65-15	151-55	W	10
Beaver Creek	-47	14770	74	63-03	141-49	SW	2
Bethel Aprt	-28	13203	69	60-47	161-48	NNE	10
Bettles	-45	15925	75	66-55	151-31	NNW	4
Big Delta/Allen AAF	-43	13698	76	64-00	145-44	S	4
Big Mountain	-13	12144	61	59-23	155-13	N	10
Black Rapids	-30	12553	73	63-29	145-50	S	4
Blair Lake AF Range	-46	14068	77	64-23	147-41	S	2
Canyon Creek	-37	13298	75	64-18	146-32	S	4
Cape Lisburne AFS	-31	17063	56	68-53	166-07	ESE	7
Cape Newenham AFS	-11	11481	58	58-39	162-04	N	11
Cape Romanzof AFS	-14	13130	59	61-47	166-02	NE	18
Cape Sarichef	12	9985	58	54-36	164-55	NNW	14

*** NOTE: Locations in units of degrees-minutes (Latitude N, Longitude W).

TABLE #4

DESIGN WEATHER DATA

Station	Winter Design Dry Bulb Temperature	Heating Degree Days	Summer Design Dry Bulb Temperature	Location *** N. Lat.	W. Long.	Pvlg. Wind (Dir)	Mean Speed (Knots)
Cathedral	-51	15275	75	63-23	143-47	SW	2
Clam Gulch	-21	11375	64	60-13	151-25	NNE	4
Clear AFS	-47	14060	77	64-20	149-10	E	4
Cold Bay AFS	9	9865	57	55-12	162-43	NNW	14
Cordova	-2	9765	66	60-30	145-29	E	5
Diamond Ridge	2	10394	61	59-41	151-37	NE	6
Donnelly	-30	12683	72	63-47	145-51	S	4
Driftwood Bay AFS	11	10637	59	53-58	166-53	N	15
Dutch Harbor	16	9197	63	53-53	166-32	N	12
Eielson AFB	-48	14498	77	64-40	147-06	S	2
Fairbanks IAP	-47	14344	78	64-49	147-52	N	3
Fort Greely	-43	13698	76	63-58	145-44	S	4
Fort Richardson/ Bryant AAF	-16	10722	68	61-16	149-39	NE	4
Fort Wainwright	-47	14344	78	64-50	147-37	N	3
Fort Yukon AFS	-57	16084	77	66-34	145-15	SW	3
Galena	-46	15087	75	64-44	156-56	NW	3
Gerstle River	-41	13398	76	63-48	145-00	S	4
Gold King Creek	-35	13364	74	62-12	149-55	E	10
Granite Mountain	-32	14986	60	65-26	161-14	N	9
Gulkana	-40	13938	75	62-09	145-27	NNW	3
Harding Lake	-41	13398	76	64-24	146-57	S	4
Homer	-2	10364	63	59-38	151-30	NE	6
Hoonah	0	9552	68	58-07	135-25	N	7

*** NOTE: Locations in units of degrees-minutes (Latitude N, Longitude W).

TABLE #4

DESIGN WEATHER DATA

Station	Winter Design Dry Bulb Temperature	Heating Degree Days	Summer Design Dry Bulb Temperature	Location *** N. Lat.	Location *** W. Long.	Pvlg. Wind (Dir)	Mean Speed (Knots)
Iliamna	-19	12144	68	59-45	154-55	NNW	8
Indian Mountain AFS	-40	15169	72	66-00	153-42	NW	3
Juneau MAP	1	9007	70	58-22	134-35	N	7
Kalakaket Creek	-32	13942	72	64-26	156-50	NW	3
Kenai MAP	-23	11615	64	60-34	151-15	NNE	4
King Salmon	-22	11582	69	58-42	156-40	N	7
Knob Ridge	-49	15080	75	63-38	144-03	SW	2
Kodiak	13	8860	65	57-45	152-29	WNW	14
Kotzebue	-37	16039	64	66-52	162-38	NE	6
Lonely	-41	20265	53	70-55	153-15	SW	8
McCallum	-26	13343	70	63-14	145-38	NNW	3
McGrath MAP	-47	14487	74	62-58	155-37	NW	2
Middleton Island	21	8188	60	59-27	146-18	NNE	15
Moses Point	-35	14505	66	64-42	162-03	N	5
Murphy Dome AFS	-32	13795	71	64-57	148-21	N	3
Naknek	-12	11133	69	58-45	157-00	N	7
Naptowne	-26	12054	72	60-32	150-35	NNE	4
Neklason Lake	-22	11220	75	61-37	149-15	NE	4
Nenana	-50	14539	77	64-33	149-05	E	4
Nikolski AFS	21	9555	56	52-58	168-51	N	15
Nome MAP	-27	14325	62	64-30	165-26	N	4
North River	-33	14027	64	63-53	160-31	ESE	6
Northway Airport	-53	15634	75	62-57	141-56	SW	2

*** NOTE: Locations in units of degrees-minutes (Latitude N, Longitude W).

TABLE #4

DESIGN WEATHER DATA

Station	Winter Design Dry Bulb Temperature	Heating Degree Days	Summer Design Dry Bulb Temperature	Location *** N. Lat.	W. Long.	Pvlg. Wind (Dir)	Mean Speed (Knots)
Ocean Cap	5	9533	63	59-32	139-51	E	6
Oliktok	-41	20265	53	70-31	149-53	SW	8
Paxson Lake	-25	13483	69	62-58	145-28	NNW	3
Pedro Dome	-33	13600	72	65-02	147-30	N	10
Pillar Mountain	10	9925	62	57-47	152-26	WNW	14
Point Barrow	-41	20265	53	71-19	156-38	SW	8
Point Lay	-37	19194	55	69-44	163-01	ESE	7
Port Heiden	-6	10441	62	56-59	158-38	NNW	11
Port Moller	-1	10290	57	55-59	160-30	NNE	12
Rabbit Creek	-13	10814	65	61-05	149-44	NE	5
St. Paul Island	4	11119	50	57-09	170-13	N	16
Sawmill	-18	13531	69	61-48	148-19	NE	4
Seward Rec Annex	7	9242	68	60-07	149-24	NE	6
Shemya AFB	24	9573	52	52-43	174E-05	NW	16
Sitka	17	8132	65	57-03	135-20	E	8
Smuggler Cover	17	7053	70	55-05	131-35	NE	12
Soldotna	-23	11615	64	60-32	151-05	NNE	4
Sparrevohn AFS	-26	12982	67	61-06	155-35	N	9
Starisky Creek	-20	10885	65	59-53	151-47	NNE	4
Tahneta Pass	-18	14361	66	61-50	149-19	N	12
Talkeetna	-48*	11708	91	62-20	150-05		
Tanana	-48	15116	76	65-10	152-06	W	4
Tatalina AFS	-28	13453	71	62-54	155-58	E	4
Tin City AFS	-27	16192	55	65-34	167-55	N	20
Tolsona	-27	12763	72	62-06	146-10	N	8
Unalakleet	-34	14027	65	63-53	160-48	ESE	6

*** NOTE: Locations in units of degrees-minutes (Latitude N, Longitude W).

TABLE #4

DESIGN WEATHER DATA

Station	Winter Design Dry Bulb Temperature	Heating Degree Days	Summer Design Dry Bulb Temperature	Location *** N. Lat.	W. Long.	Pvlg. Wind (Dir)	Mean Speed (Knots)
Valdez	-20	10545	85**	61-08	146-21		
Wainwright	-41	19991	53	70-36	159-53	SW	6
Whittier	5	9444	70	60-47	148-41	NE	4
Yakataga	10	9222	63	60-04	142-25	E	6
Yakutat	5	9533	63	59-31	139-40	E	6

* Lowest of Record
** Highest of Record

*** NOTE: Locations in units of degrees-minutes (Latitude N, Longitude W).

120

or local weather experience may be used for locations not listed.

5.3.2.2 **Indoor Design Conditions:** Although the recommended design points are established below, the system design should permit operating at minimum energy levels and at comfort conditions consistent with the criteria of ANSI/ASHRAE Standard 55-74 "Thermal Environmental Conditions for Human Occupancy" (Reference 5).

Winter:

The recommended heating design condition is 70 degrees F dry bulb. If humidification is provided, it shall be designed to a maximum relative humidity of 20%.

Summer:

Where comfort cooling is required or used, the recommended design condition is 78 degrees dry bulb. The actual design relative humidity within the comfort envelope as defined in ANSI/ASHRAE Standard 55-74 (Reference 5) shall be selected for minimum total HVAC system energy use when considering air quantities, system type, etc.

5.3.2.3 **Ventilation Standards:** The amounts of ventilation air brought into the building shall conform to ASHRAE/ANSI Standard 62-81 "Natural and Mechanical Ventilation" (Reference 6). The minimum column for each type of occupancy shall be used.

Occupancy levels used for computing outside air quantities shall be based on State of Alaska Department of Education guidelines.

5.3.2.4 **Infiltration:** Infiltration quantities for heating and ventilating design loads shall be calculated using Table 5. These rates are to be used only for sizing heat generation system equipment, and should be used in conjunction with safety factors as dictated by local practice. Pipe and duct sizing and

TABLE 5

NATURAL VENTILATION RATE (AC/HR)

Type of Construction	Design Temperature Difference											
	10	20	30	40	50	60	70	80	90	100	110	120
TIGHT	.14	.18	.22	.25	.58	.32	.36	.40	.44	.47	.51	.54
MEDIUM	.42	.50	.57	.64	.72	.80	.87	.94	1.02	1.10	1.17	1.25

terminal heating unit sizing shall be accomplished using ASHRAE Handbook 1981 Fundamentals Volume (Reference 2).

"Tight" construction results from extreme care being taken with vapor and /or air retarder construction, minimum window areas, and doors on one side of the building.

"Medium" construction results from moderate care being taken with vapor and/or air barrier construction, medium amounts of window and door areas distributed on two or more walls of building.

Where the building is to be situated in areas of known extremes in high wind and cold temperature conditions, such as Alaska's coastal areas, air change rates should be adjusted upward, in accordance with local practice.

5.4 Allowable Systems Design Concepts:

This section defines allowable mechanical system design concepts that are recommended for use in small rural school systems.

5.4.1 Hydronic Based Systems:

These systems shall consist of multiple boiler systems with perimeter baseboard, cabinet unit heaters, heating and ventilating units, and unit heaters as prime terminal units. Modular boiler systems containing more than four modular units are not allowed. Where two boilers are used, each boiler shall be sized to handle design heating load. Where three boilers are used, boiler size to be 50% of total design heating load.

Mechanical ventilation systems shall be constant volume central air handlers sized to handle ventilation loads at standard occupancy. Where gymnasium facilities with bleachers are a part of the building, and where heavy crowd conditions are expected, air handlers shall be capable of supplying and tempering crowd condition ventilation air quantities. Boilers and hydronic piping shall be sized to handle this ventilation load under design conditions. A maximum of three central air handler units are allowed.

5.4.2 Combined Heating/Ventilation Systems:

These systems shall be packaged hot air furnace equipment. A minimum of two and maximum of four units shall be provided. Each furnace shall be sized to handle 100% of computed design load for zone being supplied. Each furnace shall be capable of tempering outside air quantities required for zone ventilation requirements.

5.4.3 System Applicability:

The designer is to recognize remoteness of site and specify system concept accordingly, conforming to the following criteria:

* Hydronic based systems tend to be more complex systems that offer the most energy efficient design options, but represent a relatively high maintenance/operations profile. For these systems, technically knowledgeable people are required on staff. These systems are recommended for sites relatively close to transportation centers, and where competent maintenance staff are available.

* Combined heating/ventilation systems. These systems find application in remote Alaskan communities, where limited technically competent maintenance staff are available.

* The use of distributed unit ventilator equipment with outside air tempering capabilities is discouraged for climate regions 1,3,5,6 and 7.

5.4.4 Use of Heat Recovery:

Air to air heat recovery devices for use with toilet/locker exhaust air systems should be considered, where technically competent maintenance staff will be available. Prior to inclusion of heat recovery in a design, an economic analysis of the concept should be accomplished. This analysis should include evaluation of total annual amounts of energy recovered (savings) and the total cost of installation and operation of the system. System design concepts employed shall include a means of controlling frost build up on exhaust air stream surfaces.

5.5 Controls Design Concepts:

Control systems for heating and ventilating systems shall reflect the remoteness of the site, and shall provide for basic temperature and ventilation control for the building, as described herein. It is the intent of the Standard that the availability of competent maintenance staff be considered when designing controls.

Where competent maintenance is available, more automatic controls may be used. For small facilities at remote locations, control sequences may be simplified to allow manual adjustment of various setpoints for different climate conditions.

5.5.1 Temperature Controls:

Each system shall be provided with at least one thermostat for the regulation of temperature. Each thermostat shall be capable of being set by adjustment or selection of sensors as follows:

a. Where used to control heating only: 55 to 75 degrees F.

b. Where used to control cooling only: 70 to 85 degrees F.

c. Where used to control both heating and cooling, it shall be capable of being set from 55 to 85 degrees F and shall be capable of operating the system heating and cooling in sequence. The thermostat and/or control system shall have an adjustable deadband of up to 10 degrees F. Deadband is defined as the temperature range in which no heating or cooling energy is used.

5.5.2 Humidity Control:

If a system is equipped with a means for adding moisture to maintain specific selected relative humidities in spaces or zones, a humidistat shall be provided. This device shall be capable of being set to prevent new energy from being used to produce space relative humidity above 20 percent.

5.5.3 Zoning:

At least one thermostat for regulation of space temperature shall be provided for:

a. Each separate system.

b. Each separate zone. As a minimum each floor of a building shall be considered as a separate zone. On a multi-story building where the perimeter system offsets only the transmission losses of the exterior wall, an entire side of uniform exposure may be zoned separately. A readily accessible manual or automatic means shall be provided to partially restrict or shut off the heating and/or cooling input (for the exposure) to each floor.

5.5.4 Controls Setback and Shutoff:

Each system shall be equipped with a readily accessible means of shutting off or reducing the energy used during periods of non-use or alternate uses of the building spaces or zones served by the system. The following are examples that meet this requirement:

a. Manually adjustable automatic timing devices.

b. Automatic control systems.

5.5.5 Ventilation Control sequencing:

Hydronic based systems with ventilation air handlers employing outside air cooling shall be provided with the following minimum control sequencing:

a. Outside and return air dampers shall modulate to maintain mixed air temperature.

b. Outside air damper shall have minimum positioner to provide minimum amount of outside air for ventilation.

c. Outside air dampers shall cycle to minimum position prior to control valve opening on preheat coil.

d. Setpoint on mixed air temperature controller to be adjustable, and shall be set at minimum 60 degrees F, or that temperature necessary to prevent overheating.

e. Supply air temperature set point shall be adjustable from 60 to 75 degrees F.

5.5.6 Use of Economizer Cycle:

On larger systems at non-remote locations, each ventilation system shall be designed to use up to and including 100% of the fan system capacity for cooling with outdoor air automatically. Activation of economizer cycle shall be controlled by sensing outdoor dry-bulb temperature.

Exceptions: Cooling with outdoor air is not required under any one or more of the following conditions:

a. When energy recovered from an internal/external zone heat recovery system exceeds the energy conserved by outdoor air cooling on an annual basis.

b. When space cooling is accomplished by a circulating liquid which transfers space heat directly or indirectly to a heat rejection device such as a cooling tower without the use of a refrigeration system.

5.5.7 Scheduling Outside Air Ventilation:

Each mechanical ventilation system (supply and/or exhaust) shall be equipped with a readily accessible switch or other means for shutoff or volume reduction when ventilation is not required. Automatic or gravity dampers that close when the system is not operating shall be provided for outdoor air intakes and exhausts. Automatic or manual dampers installed for the purpose of shutting off outside air intakes and exhausts for ventilation systems shall be designed with tight shutoff characteristics to minimize air leakage.

5.6 Transport Energy:

Mechanical systems shall be designed to minimize the consumption of electrical energy in the energy conversion and transportation system within the building. Installed capacity for ventilation fans, pumps, and burners shall not exceed 1.2 horsepower per 1000 square feet of floor area. This criteria shall not include the following:

* Pumps and fans provided as standby equipment.

* Any pumps and fans with horsepowers less than or equal to 1/6 horsepower.

* Any pumps and fans that operate less than 1000 hours per year.

Installed horsepower for machinery that operates at variable power output, such as variable air volume ventilation fans, shall be computed at average operating horsepower output.

5.7 Piping Insulation:

All piping installed to serve buildings and within buildings shall be thermally insulated in accordance with Table 6. (For service water heating systems see Section 7.)

Exceptions: Piping insulation is not required in any of the following cases:

a. Piping installed within HVAC equipment.

b. Piping at fluid temperatures between 13 to 49 degrees C (55 to 120 degrees F).

c. When the heat loss and/or heat gain of the piping, without insulation, does not increase the energy requirements of the building.

5.7.1 Other Insulation Thicknesses:

Insulation thicknesses in Table 6 are based on insulation having thermal resistivity in the range of 4.0 to 4.6 Hrs-sq.ft.-deg.F/BTU-inches on a flat surface at a mean temperature of 75 degrees F. Minimum insulation thickness shall be increased for materials having R-values less than 4.0 Hrs-sq.ft.-deg.F/BTU-inches, or may be reduced for materials having R-values greater than 4.6 Hrs-sq.ft.-deg.F/BTU-inches.

a. For materials with thermal resistivity greater than 4.6 Hrs-sq.ft.-deg.F/BTU-inches the minimum insulation thickness may be deduced as follows:

$$\text{New Minimum Thickness} = \frac{4.5 \times TT}{\text{Actual R}}$$

where: TT = Table 6 Insulation Thickness

b. For materials with thermal resistivity less than 4.0 Hrs-sq.ft.-deg.F/BTU-inches, the minimum insulation thickness shall be increased as follows:

TABLE 6

MINIMUM PIPE INSULATION

Piping System Types	Fluid Temperature Range F	Insulation Thickness for Pipe Sizes		
		1" & Less	1-1/4" to 2"	2-1/2" to 4"
Heating Systems Hot Water				
Moderate Temperature	201 - 250	1.5	1.5	2.0
Low Temperature	120 - 200	1.0	1.0	1.5
Steam Condensate (for Feed Water)	Any	1.0	1.5	2.0
Chilled Water (Cooling)	40 - 55	0.5	0.75	1.0

$$\text{New Minimum Thickness} = \frac{4.0 \times TT}{\text{Actual R}}$$

where: TT = Table 6 Insulation Thickness

5.7.1.1 The required minimum thicknesses do not consider condensation. Additional insulation with vapor retarders may be required to prevent condensation under some conditions.

5.8 Air Handling System Insulation:

All ducts, plenums and enclosures installed in or on buildings shall be thermally insulated as follows:

All duct systems, or portions thereof, shall be insulated to provide a thermal resistance, excluding film resistances, of

R = Delta T/15 Hrs-sq.ft.-deg.F/BTU

where Delta T is the design temperature differential between the air in the duct and the duct surface in degrees F.

Ranges of R-Values are presented in Table 7.

TABLE 7

REQUIRED R-FACTORS
(Hrs-sq.ft.-deg.F/BTU)

Delta T Degrees F	R
27	1.8
54	3.6
81	5.4
108	7.2
136	9.1
162	11.0

Exceptions: Duct insulation is not required in any of the following cases:

a. Where Delta T is 25 degrees F or less.

b. Ducts in crawl spaces shall be insulated, except where duct heat loss is required to offset crawl space heat loss.

c. When the heat gain or loss of the ducts, without insulation, will not increase the energy requirements of the building.

d. Within HVAC equipment.

e. Exhaust air ducts.

5.8.1 The required thermal resistances do not consider condensation. Additional insulation with vapor barriers may be required to prevent condensation under some conditions.

5.9 Duct Construction:

All ductwork shall be constructed and erected in accordance with the following Sheet Metal and Air Conditioning Contractors National Association, Inc. Standards:

a. Heating and Air Conditioning Systems Installation Standards, 3rd Edition February 1977.

b. Low Pressure Duct Construction Standards, 5th Edition, 1976.

c. Fibrous Glass Duct Construction Standards, 4th Edition, 1975.

All ductwork to be low pressure.

There is no Standard at this time for leak testing of low pressure ducts. When low pressure supply air ducts are located outside of the conditioned space (except return air plenums), all transverse joints shall be sealed using mastic or mastic plus tape. For fibrous glass ductwork, pressure sensitive tape is acceptable.

5.10 Balancing

The system design shall provide means for balancing the air and water systems. In so doing these considerations shall include but not be limited to dampers, temperature and pressure test connections and balancing valves.

6.0 HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) EQUIPMENT

Terminology used in this Standard conforms to that used in the referenced ASHRAE Standard 90A (Reference 1). Section 6 HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) EQUIPMENT from ASHRAE Standard 90A is included as Appendix B.

7.0 SERVICE WATER HEATING

Terminology used in this Standard conforms to that used in the referenced ASHRAE Standard 90A (Reference 1). Section 7 SERVICE WATER HEATING from ASHRAE Standard 90A is included as Appendix B.

8.0 ENERGY DISTRIBUTIONS SYSTEMS

There is at present no Standard for energy distribution systems outside of buildings. Systems shall be designed for maximum energy efficiency, using the following design concepts:

* Temperatures for heating and cooling mediums shall be selected to minimize temperature gradients between mediums and ambient areas.

* Piping insulation shall be adequate for temperatures of heating and cooling mediums.

* Piping shall be sized to balance pressure drops (pumping energy) and piping surface areas (heat loss).

* The use of steam as a medium for energy distribution is not allowed, except where necessary for process energy requirements, or where the use of steam will result in reductions in energy loss and pumping costs for energy distributions.

9.0 LIGHTING SYSTEMS

9.1 Purpose:

The purpose of this lighting Standard is to conserve energy by providing an upper limit of power consumed to provide the lighting needs for educational facilities, in accordance with a given set of criteria and given calculation procedures.

9.2 Scope:

This Standard is not designed to be used as the total lighting design procedure; its purpose is solely to outline a process for determining the maximum power limit for regulated educational facility lighting.

9.3 General:

The provisions of this Standard establish the maximum watts allowed per square foot of floor area for interior and exterior illumination of educational facilities.

9.3.1 Exception:

In lieu of the watts per square foot procedures set forth in this Standard, the designer may design the interior lighting requirements in accordance with ASHRAE Standard 90A, Section 9 (Reference 1). ASHRAE Standard 90A, Section 9, is herewith adopted as part of these Standards by reference. If ASHRAE Standard 90A is used, the Lighting Power Budget shall be used. In developing the Lighting Power Budget, the designer is encouraged to minimize power consumption.

9.4 Design Procedure Using Watts Per Square Foot of Floor Areas:

To establish the maxiumum lighting load under the watts per square foot method, the following procedure shall be used.

9.4.1 Interiors:

a. Categories of the buildings occupancy areas with Table 8.

b. Multiply the assigned watts per square foot for the listed use by the gross floor area in square feet included in that category.

c. In rooms with ceiling height in excess of twenty (20) feet, the watts per square foot of room area may be increased by two percent per foot of height above 20 feet, to a maximum of twice the use limit in Table 8.

9.4.2 Exteriors:

a. Multiply the assigned watts given in Table 8 by the linear feet of the building perimeter to arrive at the lighting power budget for facade lighting.

b. For other exterior lighting, multiply the assigned watts given in Table 8 by the square footage of area to be illuminated.

9.4.3 Lighting Power Budget:

Add the total watts for each use area to arrive at the lighting power budget for the building. Lighting power budgets shall be calculated separately for the building interior and exterior. Total watt budget shall not exceed the allowable budget calculated from Table 8.

9.4.4 Exceptions:

a. Speciality lighting shall not be included in the building lighting power budget.

b. Lighting for, but not limited to, theatrical, television, spectator sports and like performance areas are not included in the building lighting power budget, nor is the area to be included in the computation of gross floor area.

9.5 Documentation:

Lighting calculations and/or plans shall be submitted for review unless waived in writing. The data shall provide for each use category defined in Table 8, including total area (square feet); identification of each lighting fixture; its total watts consumption; and the total lighting power budget load in watts/square feet for the area.

TABLE 8

MAXIMUM LIGHTING POWER DENSITIES

Type of Use Categories	Maximum Watts per Square Foot
Interior:	
Auditoriums and Theaters	1.1
Libraries	2.1
Office	2.5
Schools -	
a) Administration, Support Areas	1.9
b) Classroom Areas	2.1
c) Gymnasiums	1.5
Exterior:	
Facade Lighting	5.0 (per linear foot)
Outdoor Parking and Landscape Lighting	0.1 (per square foot)

Any use category not mentioned specifically may be classified in the use which it most nearly resembles.

9.6 Lighting Switching:

Switching shall be provided for each lighting circuit, or portion of each circuit, so that:

a. Lighting may be operated selectively for custodial services.

b. Lighting in task areas larger than 100 square feet can be reduced by at least one-half when the task is not being performed or is relocated.

c. Lighting can be turned off when an area is empty and not used.

d. Lighting can be reduced or turned off (manually or automatically) where daylighting is adequate and can be used effectively.

10.0 ENERGY REQUIREMENTS FOR BUILDING DESIGN ON SYSTEMS ANALYSIS

Terminology used in this Standard conforms to that used in the referenced ASHRAE Standard 90-75 (Reference 10). Section 10 ENERGY REQUIREMENTS FOR BUILDING DESIGN ON SYSTEMS ANALYSIS from ASHRAE Standard 90-75 is included as Appendix C.

11.0 REQUIREMENTS FOR BUILDINGS UTILIZING SOLAR, GEOTHERMAL, WIND OR OTHER NON-DEPLETING ENERGY SOURCES

Terminology used in this Standard conforms to that used in the referenced ASHRAE Standard 90-75 (Reference 10). Section 11 REQUIREMENTS FOR BUILDINGS UTILIZING SOLAR, GEOTHERMAL, WIND OR OTHER NON-DEPLETING ENERGY SOURCES from ASHRAE Standard 90-75 is included as Appendix C.

12.0 REFERENCES

1. American National Standards Institute/American Society of Heating, Refrigerating & Air-Conditioning Engineers/Illuminating Engineers Society, "ASHRAE Standard: Energy Conservation in New Building Design", Standards 90A-1980, 90B-1975, 90C-1977.

2. American Society of Heating, Refrigerating & Air-Conditioning Engineers, "ASHRAE Handbook and Product Directory, Fundamentals Volume", 1981.

3. Zarling, Dr. John and Strandberg, James S., Report Supplement: "Thermal and Cost Analysis of Thermal Envelopes for a Small Rural School", State of Alaska, Department of Transportation and Public Facilities, Research Section, Research Report #AKRD 83-3, 1983.

4. American National Standards Institute/American Society of Testing & Materials, "Standard Method of Test for Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors", Standard E 283-73.

5. American Society of Heating, Refrigerating & Air-Conditioning Engineers, "Thermal Environmental Conditions for Human Occupancy", Standard 55-74.

6. American Society of Heating, Refrigerating and Air-Conditioning Engineers, "Natural and Mechanical Ventilation", Standard 62-81.

7. Sheet Metal and Air-Conditioning Contractor's National Association, "Heating and Air Conditioning Systems Installation Standards", 3rd Edition, February 1972.

8. Sheet Metal and Air Conditioning Contractor's National Association, "Low Pressure Duct Construction Standards", 5th Edition, 1976.

9. Sheet Metal and Air Conditioning Contractor's National Association, "Fibrous Glass Duct Construction Standards", 4th Edition, 1975.

10. American National Standards Institute/American Society of Heating, Refrigerating & Air-Conditioning Engineers/Illuminating Engineers Society, "ASHRAE Standard: Energy Conservation in New Building Design", Standard 90-75, 1975.

APPENDIX A

Section 3

ASHRAE Standard 90A

3.0 DEFINITIONS

The following definitions are stipulated for the purposes of this document:

accessible (as applied to equipment). Admitting close approach because not guarded by locked doors, elevation or other effective means. (See *readily accessible.*)[1]

air conditioning, comfort. The process of treating air to control simultaneously its temperature, humidity, cleanliness and distribution to meet the comfort requirements of the occupants of the conditioned space.[2]

air transport factor. The ratio of the rate of useful sensible heat removal from the conditioned space to the energy input to the supply and return fan motor(s), expressed in consistent units and under the designated operating conditions.

automatic. Self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature or mechanical configuration. (See *manual.*)[1]

BBL. Barrel of oil, 159 litres (42 U.S. liquid gallons) Nominal Higher Heating Value 5.924 GJ/BBL (5.615×10^6 Btu/BBL) for crude oil, 6.145 (5.825×10^6) for No. 2 distillate fuel oil and 6.633 (6.287×10^6) for residual oil. (Source: "Monthly Energy Review", DOE National Information Center. See *heating value* and Chapter 14 of Ref.2).

boiler capacity. The rate of heat output in W (Btu/h) measured at the boiler outlet, at the design inlet and outlet conditions and rated fuel/energy input.

British thermal unit (Btu). Approximately the amount of heat required to raise the temperature of one pound of water by one Fahrenheit degree, at 60 F. International Steam Table Btu × 1.055 = kJ. (See *energy.*)

building envelope. The elements of a building which enclose conditioned spaces through which thermal energy may be transferred to or from the exterior or to or from unconditioned spaces exempted by the provisions of 2.1.2. (See Section 4.)

building project. A building or group of buildings, including on-site energy conversion or electric-generating facilities which utilize a single submittal for a construction permit or are within the boundary of a contiguous area under one ownership.

C = thermal conductance. The thermal transmission in unit time through unit area of a particular body or assembly having defined surfaces, when unit average temperature is established between the surfaces; $W/m^2 \cdot °C$ ($Btu/ft^2 \cdot h \cdot F$).

COP. See *coefficient of performance.*

coefficient of beam utilization (CBU). The ratio of the luminous flux (lumens) reaching a specified area directly from a floodlight or projector to the total beam luminous flux.[3]

coefficient of performance (COP)—cooling. See the following paragraphs for various definitions of COP as appropriate:

Electrically Operated HVAC System Equipment—Cooling	6.3.3
Applied HVAC System Components-Cooling	6.4.1
Heat Operated HVAC System Equipment—Cooling	Table 6.7

coefficient of performance (COP), heat pump—heating. See 6.7.3 for definition.

coefficient of utilization (CU). The ratio of the luminous flux (lumens) from a luminaire received on the work plane to the lumens emitted by the luminaire's lamps alone.

color rendition. General expression for the effect of a light source on the color appearance of objects in conscious or subconscious comparison with their color appearance under a reference light source.

comfort envelope. The area on a psychrometric chart enclosing all those conditions described in ANSI/ASHRAE Standard 55-74[4], Fig. 1, as being comfortable.

conditioned floor area. The horizontal projection of that portion of interior space which is contained within exterior walls and which is conditioned directly or indirectly by an energy-using system.

conditioned space. Space within a building which is provided with heated and/or cooled air or surfaces and, where required, with humidification or dehumidification means so as to maintain a space condition falling within the comfort zone set forth in ANSI/ASHRAE Standard 55-74 "Thermal Environmental Conditions for Human Occupancy." (See 6.1.2 for application)

cooled space. Space within a building which is provided with a *positive cooling supply.*

degree day, heating. A unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal heating load of a building in winter. For any one day, when the mean temperature is less than 18.3°C (65 F), there are as many Degree Days as degrees Celsius (Fahrenheit) difference in temperature between the mean temperature for the day and 18.3°C (65 F).[2]

dwelling unit. A single housekeeping unit comprised of one or more rooms providing complete, independent living facilities for one or more persons including permanent provisions for living, sleeping, eating, cooking and sanitation.

EER. See *energy efficiency ratio.*

economizer cycle. A control sequence of an air supply system that modulates the quantity of outdoor air supplied for the purpose of space conditioning in order to reduce or eliminate the use of refrigeration energy for cooling.

efficiency, HVAC system. The ratio of the useful energy output (at the point of use) to the energy input for a designated time period, expressed in percent.

energy. The capacity for doing work; taking a number of forms which may be transformed from one into another, such as thermal (heat), mechanical (work), electrical, and chemical; in SI units, measured in joules (J), where 1 joule = 1 watt-second; in customary units, measured in kilowatt hours (kWh) or British thermal units (Btu).

energy efficiency ratio (EER). The ratio of net equipment cooling capacity in Btu/h to total rate of electric input in watts under designated operating conditions. When SI units are used this ratio becomes equal to COP. (See *coefficient of performance.*)

energy, recovered. (See *recovered energy.*)

energy resources. (See *resource utilization factor, resources consumed.*)

enthalpy. A thermodynamic property of a substance defined as the sum of its internal energy plus the quantity Pv/J: where P = pressure of the substance, v = its volume, and J = the mechanical equivalent of heat; formerly called total heat and heat content.

equivalent sphere illumination (ESI). The level of sphere illumination which would produce task visibility equivalent to that produced by a specific lighting environment.

exterior envelope. (See *building envelope.*)

floodlighting. A lighting system designated to light an area using projector-type luminaires usually capable of being pointed in any direction.

fuel, fossil. Depletable carbonaceous substances which may be oxidized to produce heat or chemically combined to produce electricity (e.g., fuel cell). The heat may be utilized directly or used to produce electricity.

fuel, nuclear. Depletable radioactive substances which, through the process of controlled fission, produce heat. The heat may be utilized directly or used to produce electricity.

gross floor area. The sum of the areas of the several floors of the building, including basements, mezzanine and intermediate-floored tiers and penthouses of headroom height, measured from the exterior faces of exterior walls or from the centerline of walls separating buildings, but excluding:

- Covered walkways, open roofed-over areas, porches and similar spaces.

- Pipe trenches, exterior terraces or steps, chimneys, roof overhangs, and similar features.

gross wall area. See 4.2.2 for definition.

HHV. Higher heat value (See *heating value*).

HVAC. Heating, ventilating and air conditioning.

HVAC system. A system that provides either collectively or individually the processes of comfort heating, ventilating, and/or air conditioning within or associated with a building.

HVAC system component. (See 6.1.2.2 and *HVAC system equipment*)

HVAC system equipment. (See 6.1.2.1) The word "equipment," used without modifying adjective, may in accordance with common industry usage, apply either to HVAC system equipment or HVAC system components.

HVAC system efficiency. (See *efficiency, HVAC system.*)

heat. The form of energy that is transferred by virtue of a temperature difference.[2]

heated space. Space, within a building, which is provided with a *positive heat supply*. Finished living space within a basement, or registers or heating devices designed to supply heat to a basement space, shall automatically define that space as *heated space.*

heating value. The amount of heat produced by the complete combustion of a unit quantity of fuel. The gross or Higher Heat Value (HHV) is that which is obtained when all of the products of combustion are cooled to the temperature existing prior to combustion and any water vapor formed during combustion is condensed (contributes the latent heat of vaporization). For fuels containing hydrogen, the net or Lower Heating Value (LHV) is obtained by deducting the latent heat of vaporization of the water vapor, formed by the combustion of the hydrogen in the fuel, from the Higher Heat Value (See *BBL*).

humidistat. A regulatory device, actuated by changes in humidity, used for automatic control of relative humidity.

illumination. The density of the luminous flux incident on a surface; it is the quotient of the luminous flux by the area of the surface when the latter is uniformly illuminated.

infiltration. The uncontrolled inward air leakage through cracks and interstices in any building element and around windows and doors of a building, caused by the pressure effects of wind and/or the effect of differences in the indoor and outdoor air density.

LHV. Lower heating value (See *heating value*).

light loss factor (LLF). A factor used in calculating the level of illumination after a given period of time and under given conditions. It takes into account temperature and voltage variations, dirt accumulation on luminaire and room surfaces, lamp depreciation, maintenance procedures, and atmosphere conditions.

luminaire. A complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps, and to connect the lamps to the power supply.

MCF. Customary term for one thousand cubic feet (28,320 *l*).

manual. Capable of being operated by personal intervention (adjective). (See *automatic.*)

manufactured building. Any building (except a mobile home) which is of closed construction and which is made or assembled in manufacturing facilities on or off the building site, or any building of open construction which is made away from the building site for installation or assembly and installation on the building site.

marked rating. The design load operating conditions of a device as shown by the manufacturer on the nameplate or otherwise marked on the device.

mobile home. A factory-assembled, movable dwelling designed and constructed to be towed on its own chassis, comprised of frame and wheels, usually used without a permanent foundation, and distinguishable from other types of dwellings in that the standards to which it is built include provisions for its mobility on that chassis as a vehicle.

multi-family dwelling. A building containing three or more dwelling units.

non-depletable energy sources. Sources of energy (excluding minerals) derived from: incoming solar radiation, including natural daylighting and photosynthetic processes; phenomena resulting therefrom including wind, waves and tides, lake or pond thermal differences; and energy derived from the internal heat of the earth, including nocturnal thermal exchanges. (See *solar energy source*).

OTTV. Overall thermal transfer value. The maximum thermal transfer permissible into the building through its walls or roof, due to solar heat gain and outdoor- indoor temperature difference, as determined by the equation appearing in Section 4.

opaque areas. All exposed areas of a building envelope which enclose conditioned space, except openings for windows, skylights, doors and building service systems.

outdoor air. Air taken from the outdoors and, therefore, not previously circulated through the system.

packaged terminal air-conditioner. A factory-selected combination of heating and cooling components, assemblies or sections, intended to serve a room or zone. (For the complete technical definition, see Ref. 5.)

packaged terminal heat pump. A factory-selected combination of heating and cooling components, assemblies or sections, intended for application in an individual room or zone. (For the complete technical definition, see Ref. 31.)

positive cooling supply. Mechanical cooling deliberately supplied to a space, such as through a supply register. Also, mechanical cooling indirectly supplied to a space through uninsulated surfaces of space cooling components, such as evaporator coil cases and cooling disbribution systems, which continually maintains air temperatures within the space of 29.4°C (85 F) or lower during normal operation. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this Standard.

positive heat supply. Heat deliberately supplied to a space such as a supply register, radiator or heating element. Also, heat indirectly supplied to a space through uninsulated surfaces of service water heaters and space heating components such as furnaces, boilers, and heating and cooling distribution systems, which continually maintains air temperature within the space of 10°C (50 F) or higher during normal operation. To be considered exempt from inclusion in this definition, such surfaces shall comply with the insulation requirements of this Standard.

power. In connection with machines, power is the time rate of doing work. In connection with the transmission of energy of all types, power refers to the rate at which energy is transmitted. In SI Units it is measured in joules per second (J/s) or in watts (W); in customary units, it is measured in watts (W) or British thermal units per hour (Btu/h).

public facility restroom. A restroom used by the transient public on a a regular (rather than casual) basis. Examples include restrooms in service stations, airports, train terminals and convention halls. Restrooms incorporated with private guest rooms in hotels, motels or dormitories, and restroom facilities intended for the use of employees and not usually used by the general public, are not considered public facility restrooms. (See 7.7.2.)

R. = Thermal resistance. The reciprocal of thermal conductance; $(m^2 \cdot °C)/W$ or $(hr \cdot ft^2 \cdot F)/Btu$.

RIF. (See *resource impact factor.*)

RUF. (See *resource utilization factor.*)

readily accessible. Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. (See *accessible.*)[1]

recommend. Suggest as appropriate; not required.

recooling. The removal of heat by sensible cooling of the supply air (directly or indirectly) that has been previously heated above the temperature to which the air is to be supplied to the conditioned space for proper control of the temperature of that space.

recovered energy. Energy utilized which would otherwise be wasted (i.e. not contribute to a desired end use) from an energy utilization system.

reflectance. The ratio of the light reflected by a surface to the light falling upon it.

registered engineer. An appropriately qualified and licensed professional engineer. In addition, with respect to Sections 10 and 11, this means a qualified professional engineer familiar with the climatology of the geographic area in question.

reheat. The application of sensible heat to supply air that has been previously cooled below the temperature of the conditioned space by either mechanical refrigeration or the introduction of outdoor air to provide cooling.

reset. Adjustment of the set point of a control instrument to a higher or lower value automatically or manually.

residential building. Living units of one story, two stories, or other low-rise, multi-family dwellings, not exceeding three stories above grade. (*See Type "A" Building, 4.3,* and *dwelling unit.)*

resource energy impact. The product of an energy resource (includes application of RUF) anticipated to be used in providing fuel or energy to a building site multiplied by a RIF for that particular form of energy resource. The total resource energy impact is the sum of all Resource Energy Impacts for a building project.

resource impact factor (RIF). Mutipliers applied to fuel and energy resources required by a building project to permit a quantitative evaluation of the effect on those resources resulting from the selection of on-site fuel and energy forms, giving consideration to availability, social, economic, environmental, and national interest issues.

resource utilization factor (RUF). Groups of multipliers, applied to the quantity of fuel or energy delivered to a building site, which provide quantitative estimates of the energy resources consumed in providing that fuel or energy. These multipliers account for the burden of processing, refining, transporting, converting and delivering fuel or energy from the point of extraction to the building site.

$$RUF = \frac{\text{resources consumed}}{\text{energy delivered}}$$

where:

resources consumed. The resource extracted from the earth, in standard gravimetric or volumetric units of measure—litres (*l*) of oil, kilolitres (k*l*) of natural gas, tonnes (Mg) of coal, grams (g) of uranium, etc.— required to provide the respective fuel and energy quantities supplied to the building site. Corresponding conventional units are barrels (BBL) oil, thousands of cubic feet (MCF) gas, short tons (S. Tons) coal, grams (Grams) uranium, etc. The burdens of extraction are not included.

energy delivered. The fuel and energy supplied to the building site—litres of oil, kilolitres of natural gas, tonnes of coal, gigajoules of electricity— expressed in gigajoules (Higher Heat Value for fossil fuels).(See *heating value*). For conventional units energy delivered is expressed in millions of Btu (Higher Heat Value).

room air conditioner. An encased assembly designed as a unit primarily for mounting in a window or through a wall, or as a console. It is designed primarily to provide free delivery of conditioned air to an enclosed space, room or zone. It includes a prime source of refrigeration for cooling and dehumidification and means for circulating and cleaning air, and may also include means for ventilating and heating.[6]

room cavity ratio (RCR). A number related to room dimensions used in average illumination calculations.[3]

S. Ton. Short Ton. Customary term for two thousand pounds mass [0.907 Mg (tonne)].

sequence. A consecutive series of operations.

service systems. All energy-using systems in a building that are operated to provide services for the occupants or processes housed therein, including HVAC, service water heating, illumination, transportation, cooking or food preparation, laundering or similar functions.

service water heating. Supply of hot water for domestic or commercial purposes other than comfort heating.

service water heating demand. The maximum design rate of energy withdrawal from a service water heating system in a designated period of time (usually an hour or a day).

shading coefficient (SC).

$$SC = \frac{\text{Solar Heat Gain of Fenestration}}{\text{Solar Heat Gain of Double Strength Glass}}$$

Note: To be compared under the same conditions. See Chapter 26, Ref. No. 2.

shall. Where shall is used with a special provision, that provision is mandatory if compliance with the Standard is claimed.

should. Term used to indicate provisions which are not mandatory but which are desirable as good practice.

solar energy source. Source of natural daylighting and of thermal, chemical or electrical energy derived directly from conversion of incident solar radiation (See *nondepletable energy sources*).

system. A combination of equipment and/or controls, accessories, interconnecting means, and terminal elements by which energy is transformed so as to perform a specific function, such as HVAC, service water heating or illumination.

terminal element. The means by which the transformed energy from a system is finally delivered; i.e., registers, diffusers, lighting fixtures, faucets, etc.

thermostat. An automatic control device actuated by temperature and designed to be responsive to temperature.

U = thermal transmittance. The coefficient of heat transmission (air to air). It is the time rate of heat flow per unit area and unit temperature difference between the warm side and cold side air films $W/m^2 \cdot °C$ ($Btu/ft^2 \cdot h \cdot F$). The U value applies to combinations of different materials used in series along the heat flow path, single materials that comprise a building section, cavity air spaces, and surface air films on both sides of a building element.

U_o = thermal transmittance, overall. The overall (average) heat transmission of a gross area of the exterior building envelope $W/m^2 \cdot °C$($Btu/ft^2 \cdot h \cdot F$). The U_o value applies to the combined effect of the time rate of heat flows through the various parallel paths, such as windows, doors, and opaque construction areas, comprising the gross area of one or more exterior building components, such as walls, floors, or roof/ceiling.

unitary cooling and heating equipment. One or more factory-made assemblies which normally include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function as well. Where such equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together.

unitary heat pump. One or more factory-made assemblies which normally include an indoor conditioning coil, compressor(s) and outdoor coil or refrigerant-to-water heat exchanger, including means to provide both heating and cooling functions. When such equipment is provided in more than one assembly, the separate assemblies shall be designed to be used together.[7]

veiling reflections. Regular reflections superimposed upon diffuse reflections from an object that partially or totally obscure the details to be seen by reducing the contrast. This sometimes is called reflected glare.

ventilation. The process of supplying or removing air by natural or mechanical means to or from any space. Such air may or may not have been conditioned.

ventilation air. That portion of supply air which comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space. (See Reference 8 and Section 5 of this Standard. See *outdoor air*).

Water-chilling package of absorption. A factory designed and prefabricated assembly (not necessarily shipped as a single package) of one or more condensers; evaporators (water coolers); absorbers; and generators; with interconnections and accessories, used for chilling water.

Water-chilling package, centrifugal or rotary. A factory-designed and prefabricated assembly (not necessarily shipped as one package) of one or more centrifugal or rotary compressors; condensers; and water-coolers (evaporators); with interconnections and accessories, used for chilling water.

Water-chilling package, reciprocating. A factory designed and prefabricated assembly, self-contained or condenserless, of one or more reciprocating compressors; condensers (self-contained only); water coolers (evaporator); and interconnections and accessories; used for chilling water. The condenser may be air-, evaporatively-, or water-cooled.

watt (W). SI unit of power equal to one joule per second (J/s). Also, the power delivered by one volt with one ampere flowing (unity power factor). (See *power*.)

Work plane. The plane at which work usually is done and at which the illumination is specified and measured. Unless otherwise indicated, this is assumed to be a horizontal plane 0.76 m (30 in.) above the floor.

Zone. A space or group of spaces within a building with heating and/or cooling requirements sufficiently similar so that comfort conditions can be maintained throughout by a single controlling device.

BEST COPY AVAILABLE

APPENDIX B

Sections 6 and 7

ASHRAE Standard 90A

6.0 HEATING, VENTILATING AND AIR-CONDITIONING (HVAC) EQUIPMENT

6.1 Scope. This section deals with equipment and component performance and manufacturers' documentation, in accordance with the criteria for effective utilization of on-site energy established in this Standard, for HVAC-system equipment and HVAC-system components used in new buildings. (see also 2.3)

6.1.1 This section excludes refrigerating equipment not used to heat, ventilate or air-condition buildings for human comfort.

6.1.2 HVAC Systems. For the purposes of this Section, "HVAC Systems" (defined in Sec. 3) are considered to be of three basic types:

a. Central Air-Distribution Systems. In this type, either HVAC System Equipment (6.1.2.1), or an engineered and field-assembled combination of HVAC System Components (6.1.2.2), receive recirculated room air (plus outside air as required) from a central duct system, perform the required heating, ventilating or air-conditioning functions, and deliver the conditioned air to the central duct system, for final delivery to the conditioned space(s) of the building.

b. Central Circulating Water Systems. In this type, a centrifugal, or reciprocating, compression refrigeration or absorption refrigeration type water- chilling package provides chilled water to a central piping system; either a fossil-fuel-fired or electric boiler, or central heat exchanger, provides heated water to the central piping system; and the piping system supplies heated or cooled water, as required, to water-air heat exchangers (terminal units) serving the conditioned space(s) of the building. The water chilling package, including its heat- rejecting element; the boiler; the central heat exchanger; and the terminal units are considered to be HVAC System Components.

c. Multiple Unit Systems. In this type, a number of units of HVAC Equipment, each receiving a supply of electric and/or fossil fuel energy, or in some cases steam or hot water from a central source, each performs the functions of heating and/or cooling air for distribution to a conditioned space or zone of the building.

6.1.2.1 HVAC System Equipment. HVAC System Equipment (6.3, 6.5, 6.6, 6.7, 6.8) provides, in one (single-package) or more (split system) factory- assembled packages, means for air-circulation, air- cleaning, air-cooling with controlled temperature, and dehumidification; and optionally either alone or in combination with a heating plant, the functions of heating and humidifying. The cooling function may be either electrically- or heat-operated, and the refrigerant condenser may be air-, water-, or evaporatively-cooled. Where the equipment is provided in more than one package, the separated packages shall be designed by the manufacturer to be used together. The equipment may provide the heating function as a heat pump, or by the use of electric or fossil-fuel-fired elements.

In the case of heat-operated unitary air- conditioners, established practice is for the efficiency or COP published by the manufacturer to be based only on the on-site heat-energy supplied to the unit. In this case, the system designer must add the electrical energy furnished to the unit, and to any auxiliaries or accessories, in establishing HVAC system efficiency. See also 6.5.1.

6.1.2.2 HVAC System Components. HVAC System Components (6.4, 6.6, 6.7) provide, in one or more factory-assembled packages, means for chilling and/or heating water, with controlled temperature, for delivery to terminal units serving the conditioned spaces of the building.

One type of HVAC system component is the water chilling package. The chiller may be of the centrifugal, rotary or reciprocating, electrically-driven type, or heat-operated type. In air-cooled packages, the fan-motor(s) energy is included by the manufacturer in determining the EER (COP) of the package. In water-cooled or evaporatively-cooled types, if a cooling tower or evaporative condenser is included in the package, the circulating pump motor(s) are also taken into account by the manufacturer in determining the EER (COP).

In the heat-operated types, pumps included in the package for circulating fluids in the refrigeration cycle, are not included in determining the EER (COP) of the component. Chilled water pumps circulating chilled water through the piping systems external to the package, and cooling tower pumps and fans circulating water or air through the condenser and cooling tower also are not included in the EER (COP) published by the manufacturer for the component, but their on-site energy input, as well as that for internal refrigerant circulating pumps, must be taken into account by the system designer in computing the system EER (COP) and annual energy consumption of the HVAC system.

A second type of HVAC System Component is the reciprocating condensing unit. This unit receives its suction refrigerant vapor from a packaged or field-assembled combination of cooling coil and fan (central station air handling unit), and delivers liquid refrigerant to the air handling unit. The EER (COP) of the condensing unit is based on the energy input to the condensing unit, and the change in enthalpy of the refrigerant entering and leaving the condensing unit. The energy consumed by the heat rejecting device (cooling tower or heat exchanger) is not included in the condensing unit manufacturer's published EER (COP), unless the device (i.e., air-cooled condenser) is integrally incorporated into the package by the manufacturer.

A third type of HVAC System Component, for use in a central circulating water system is the a water-source (hydronic) heat pump. Individual units are usually installed for each space or zone, in combination with a water circulating system with central boiler or heat exchangers, and central cooling tower or evaporative cooler, to produce chilled or heated air for direct delivery to each zone or space to be conditioned. In this case also, for cooling operation the EER (COP) of the system component does not include the energy for circulating water through the system or driving the cooling tower fan; for heating, the COP does not include water circulation on-site energy or on-site fossil-fuel energy for operating the boiler; these energy requirements shall be taken into account by the HVAC system designer.

6.1.3 On-Site Energy. It is recognized that virtually all types of equipment used in HVAC systems will use energy which has been extracted, refined, transported, transformed, or otherwise modified to the state in which it is delivered to the site and then used to drive the equipment. The manufacturer cannot predict the relationship between a given form of energy which will be used to drive his products and the nature, source and amount of any or all forms of source energy involved. Therefore, in this Section 6 all energy performance requirements will be based on energy as delivered at the site.

6.1.4 Minimum COP/Efficiency Levels. In succeeding portions of this Section 6, minimum COP and/or efficiency levels are established for HVAC System Equipment (6.1.2.1) and HVAC System Components (6.1.2.2). It is intended that no lower values than those established in this Section shall be acceptable. It is further intended that where equipment of higher COP/Efficiency capability is known to be available on the open market, it shall be the system designer's option to specify such higher efficiencies as he deems to be suitable.

6.2 Responsibility of HVAC System Equipment and System Component Suppliers. Suppliers of HVAC system equipment and system components shall furnish, upon request by prospective purchasers, system designers, or contractors, the input(s) and output(s) of all such HVAC products. These shall be based on equipment or components in new condition, and shall cover full load, partial load, and standby conditions, as required, to enable determination of their compliance with this Standard. This includes performance data under modes of operation and at ambient conditions necessary to make the analysis outlined in Section 10 of this Standard.

6.2.1 Where equipment efficiency levels are specified in this section, data furnished by the equipment supplier or certified under a nationally recognized certification program or rating procedure may be used to satisfy these requirements. This paragraph shall not be interpreted as removing the requirement for detailed part-load performance data, as agreed between the purchaser or designer and supplier, if requested.

6.3 Efficiency Requirements for HVAC System Equipment, Electrically Operated, Cooling Mode. HVAC System Equipment as listed in 6.3.1 and qualified in 6.3.2, whose energy input in the cooling mode is entirely electric, shall, at the Standard Rating Conditions specified in Table 6.1 and additional Standard Rating Conditions specified in applicable standards for particular HVAC system equipment, have an Energy Efficiency Ratio (EER) as defined in Section 3, or a Coefficient of Performance (COP)— Cooling as defined in 6.3.3, not less than values shown in Table 6.2.*

6.3.1 These requirements apply to, but are not limited to, unitary (central) cooling equipment (air-cooled, water-cooled and evaporatively-cooled); the cooling mode of unitary (central) and packaged terminal heat pumps (air source and water source); packaged terminal air-conditioners; and room air-conditioners.

Exception. These requirements do not apply to equipment serving areas such as supermarkets, having

*Table 6.2, Notes 3, 4 and 5 indicate exceptions which shall be observed where DOE regulations apply.

67 - 51 - BEST COPY AVAILABLE

open, refrigerated food display cases, or computers or other equipment contributing a large amount of heat to the area served.

6.3.2 Where components from more than one supplier are used to function as the unitary equipment, it shall be the function of the system designer to determine compliance with these requirements, using data provided by the component supplier (See Section 6.2).

6.3.3 **Coefficient of Performance (COP)—Cooling.** This is the ratio of the rate of net heat removal to the rate of total on-site energy input to the air conditioner, expressed in consistent units and under designated rating conditions (See Tables 6.1, 6.3.1 and 6.3.2).

The rate of net heat removal shall be defined as the change in the total heat content of the air entering and leaving the equipment (without reheat).

Total on-site energy input shall be determined by combining the energy inputs to all elements supplied with the package of the equipment, including but not limited to, compressor(s), compressor sump heater(s), pump(s), supply-air fan(s), return-air fan(s), condenser-air fan(s), cooling-tower fan(s) and circulating water pump(s), and the HVAC system equipment control circuit.

6.3.3.1 In the case where any of the above elements is incorporated in the HVAC system, but not furnished as part of the package (covered by the manufacturer's Model No.), it is the system designer's responsibility to take the corresponding on-site energy inputs into account in determining the system performance and annual energy consumption.

6.4 Efficiency Requirements for Applied HVAC System Components, Electrically Operated, Cooling Mode. HVAC System Components, as listed in Tables 6.4 and 6.5, whose energy input is entirely electric, shall, at the Standard Rating Conditions specified in Table 6.3.1 for water-chillers and hydronic system water-source heat pumps, and Table 6.3.2 for condensing units, and at additional Standard Rating Conditions specified in applicable standards for particular system components, have an Energy Efficiency Ratio (EER) as defined in Sec. 3, or a Coefficient of Performance (COP)—Cooling, as defined in 6.4.1 and qualified in 6.4.2, not less than the values shown in Tables 6.4 and 6.5.

6.4.1 **Coefficient of Performance (COP)—Cooling.** This is the ratio of the rate of net heat removal to the rate of total on-site energy input, expressed in consistent units and under designated rating conditions. (See Tables 6.3.1, 6.3.2, 6.4 and 6.5).

The rate of net heat removal from the component is defined as the difference in total heat contents of the water or refrigerant entering and leaving the components.

Total on-site energy input to the component shall be determined by combining the energy inputs to all elements and accessories as included in the component, including but not limited to compressor(s), internal circulating pump(s), condenser-air fan(s), evaporative-condenser cooling water pump(s), purge devices, and the HVAC system component control circuit.

6.4.2 Where the motor-compressor, evaporator, or condenser is supplied by different manufacturers, it shall be the function of the system designer to determine compliance with these requirements, using data provided by the suppliers of the elements (see Section 6.2).

6.5 COP Requirements for HVAC System Equipment—Heat Operated, Cooling Mode

6.5.1 **Efficiency Limitation, Equipment.** Heat-operated cooling equipment shall have a COP—Cooling not less than the values shown in Table 6.7 when tested at Standard Rating Conditions shown in Table 6.6. These requirements apply to, but are not limited to, absorption equipment, engine-driven equipment, and turbine-driven equipment.

6.5.2 **Electrical Auxiliary Inputs.** Table 6.7 defines the COP for equipment in a footnote, which excludes electrical auxiliary inputs from the calculation of COP. However, this input shall be included by the system designer in the calculation of the annual energy consumption of the building, or of the total HVAC system COP.

6.6 HVAC System Combustion Heating Equipment

6.6.1 **Residential/Commercial Furnaces and Boilers.** These include oil- and gas-fired residential furnaces and boilers as defined in the Federal Register Vol. 43, No. 91-May 10, 1978, 430.2 Definitions, page 20154[39] (see Section 3); to vented home heating equipment, as defined therein; and to commercial furnaces and boilers with inputs under 117 kW (400,000 Btu/h).

6.6.1.1 **Minimum Required Steady State Efficiencies.** All gas- and oil-fired residential furnaces and boilers, and all vented home-heating equipment, shall, when tested in accordance with the applicable DOE furnace test procedures, have not less than the minimum steady state combustion efficiency specified in Table 6.8.

6.6.2 **Commercial/Industrial Furnaces and Boilers.** For the purposes of this standard, all gas- or oil-fired furnaces and boilers not included in the definitions specified in 6.6.1 shall be referred to as commercial/industrial furnaces and boilers.

6.6.2.1 **Minimum Required Steady State Efficiency.** All gas-and oil-fired commercial/industrial furnaces and boilers shall, when tested in accordance with applicable standards have not less than the minimum steady state combustion efficiency specified in Table 6.8.

6.6.2.2 **Combustion Efficiency.** Combustion efficiency of commercial/industrial furnaces and boilers is defined as 100 percent minus stack losses in percent of heat input. Stack losses are:

a. Loss due to sensible heat in dry flue gas
b. Loss due to incomplete combustion

BEST COPY AVAILABLE

c. **Loss due to sensible** and latent heat in moisture formed by combustion of hydrogen in the fuel

and shall be determined as provided by applicable standards. (See Section 6.2).

6.6.3 **Adequate Combustion Air. a. Residential/Commercial Installations. a. Residential and Commercial Installations.** For residential and commercial installations with inputs under 117 kW (400,000 Btu/h), it is the system designer's responsibility either to establish that the total minimum calculated infiltration rate will provide sufficient combustion air for fuel-fired equipment, or to provide positive means for introducing adequate outdoor air for that purpose.[32,33]

b. **Commercial/Industrial.** For commercial/industrial installations with inputs 117 kW (400,00 Btu/h) and over, a machine room, or boiler or furnace room, or installation outdoors, shall be provided as required to insure adequate direct outdoor air supply and to comply with governing local codes or ordinances.

6.7 **COP Requirements for HVAC System Heating Equipment—Heat Pumps, Heating Mode.** Heat pumps whose energy input is entirely electric, shall at the Standard Rating Conditions specified in Table 6.9 and other Standard Rating Conditions specified in applicable standards for particular types of heat pumps (see 6.7.1), have a Coefficient of Performance (COP)—Heating, as defined in 6.7.3, not less than the values shown in Table 6.10.

Note: Heat pumps used only for the heating function of a complete HVAC System shall be considered as HVAC System Components.

6.7.1 These requirements apply to, but are not limited to unitary (central) heat pumps (air source and water source) in the heating mode, to water source (hydronic) heat pumps as used in Multiple Unit Hydronic HVAC Systems and to heat pumps in the packaged terminal air-conditioner and room air-conditioner forms, in the heating mode.

6.7.2 Where elements, such as indoor or outdoor coils, from more than one supplier are used as parts of the unitary heat pump, it shall be the function of the system designer to determine compliance with these requirements, using data provided by the component suppliers (see Section 6.2).

6.7.3 **Coefficient of Performance (COP)—Heating.** This is the ratio of the rate of net heat output by the heat pump to the rate of total on-site energy input to the heat pump, expressed in consistent units and under designated rating conditions. (See Tables 6.9 and 6.10).

The rate of net heat output shall be defined as the change in the total heat content of the air entering and leaving the equipment (not including supplementary heat).

Total on-site energy input to the heat pump shall be determined by combining the energy inputs to all elements, except supplementary heaters, of the heat pump, including, but not limited to, compressor(s), compressor sump heaters, pump(s), supply-air fan(s), return-air fan(s), outdoor-air fan(s), cooling-tower fan(s), and the HVAC system equipment control circuit.

6.7.3.1 In the case where any of the above elements including supplementary heaters are incorporated in the HVAC System, but not furnished as part of the package (covered by the manufacturer's Model No.) it is the system designer's responsibility to take the corresponding on-site energy inputs into account in determining the total HVAC System performance and annual on-site energy consumption.

6.7.3.2 Most hydronic heat-pump systems utilize condenser-rejected heat from air conditioners serving building central core areas needing cooling during the heating season, or other available waste heat, to raise the temperature of the water from its value leaving the heat-pumps serving the perimeter of the building, to its required value entering the heat pumps. Where the quantity of such reclaimed heat is not sufficient, it must be supplemented by additional new on-site energy and, during cooling operation, on-site energy supplied to the evaporative cooling device. It is the system designer's responsibility to take these energies into account in determining total HVAC system performance and annual on-site energy consumption.

6.7.4 **Supplementary Heater.** The heat pump shall be installed with a control to prevent electric supplementary heater operation when the heating load can be met by the heat pump alone.

Electric supplementary heater operation is permitted during transient periods, such as start-ups, following room thermostat set-point advance, and during defrost.

A two-stage room thermostat, which controls the supplementary heat on its second stage, shall be accepted as meeting this requirement. The cut-on temperature for the compression heating shall be higher than the cut-on temperature for the supplementary heat, and the cut-off temperature for the compression heating shall be higher than the cut-off temperature for the supplementary heat. Supplementary heat may be derived from any source including, but not limited to, electric resistance heating, combustion heating, or solar or stored-energy heating.

6.8 **Electric Resistance Comfort Heating Equipment.** The manufacturer of electric resistance comfort heating equipment shall make available to prospective purchasers, designers, or contractors, upon request, full-load energy input, over the range of voltages at which the equipment is intended to operate. Where electrically-operated fans, blowers or pumps are integrally incorporated, or separately furnished, their electrical input shall be included by the system designer as part of the energy input to the equipment.

6.9 **Maintenance.** Equipment and components which require preventive maintenance to maintain efficient operation shall be furnished with complete necessary maintenance information. Required routine maintenance actions shall be clearly stated and incorporated on a readily accessible label, which may be limited to identifying, by title and/or publication number, the

operation and maintenance manual for that particular model and type of product.

At least one copy of this information shall be furnished by the manufacturer for the original owner upon request.

In installations that are made up of more than one item of equipment or components, efficient operation of any one device may be dependent on proper maintenance of one or more other components of the system. Under such conditions, it is the function of the system designer to provide, or cause to be provided, for the original owner, upon request, the necessary maintenance information for the installation.

Table 6.1
HVAC System Equipment, Electrically Driven[1]
Standard Rating Temperatures[2] Cooling

Item		Air-Cooled		Water-Cooled (Water-Source)	
		Dry-Bulb (DB)	Wet-Bulb (WB)	Inlet	Outlet
Room Air Entering Equipment	°C (F)	26.7 (80)	19.4 (67)	—	—
Condenser Ambient (Air Cooled)	°C (F)	35.0 (95)	23.9 (75)	—	—
Refrigerant-Water Heat Exchanger[3]	°C (F)	—	—	29.4 (85)	35.0 (95)

1. Data in this Table 6.1 apply to the following types of equipment:
   Central Air Conditioners-Air-, Evaporatively- and Water-Cooled, ARI Std. 210-78
   Commercial/Industrial Unitary Air-Conditioning Equipment, ARI Std. 360-75
   Central Unitary Heat Pumps—Air Source, ARI Std. 240-77 (Cooling Mode)
   Central Unitary Heat Pumps—Water Source, ARI Std. 320-76 (Cooling Mode)
   Commercial and Industrial Unitary Heat Pumps-Air and Water Source, ARI Std. 340-76 (Cooling Mode)
   Packaged Terminal Air-Conditioners, ARI Std. 310-76
   Packaged Terminal Heat Pumps, ARI Std. 380-78 (Cooling Mode)
   Room Air-Conditioners, ANSI Z234.1-1972
2. Standard Ratings are also based on other Standard Rating Conditions, such as, but not limited to, electrical conditions; cooling coil air quantity; condenser air quantity; requirements for separated (split) assemblies; and minimum external static conditioned-air flow resistances, as provided in the applicable standards.
3. Refrigerant-Water Heat Exchanger serves as Condenser in Cooling Mode, and as Evaporator in Heating Mode, of Water Source Heat Pumps.

Table 6.2
HVAC System Equipment, Electrically Driven[1]
Minimum COP (EER)—(Cooling)[2,3,4,5]

Effective Date	Standard Rating Capacities			
	Under 19 kW (65,000 Btu/h)		19 kW (65,000 Btu/h) and Over	
	Air-Cooled	Evap. or Water Cooled	Air-Cooled	Evap. or Water Cooled
Beginning January 1, 1980	1.99 (6.8)	—	2.20 (7.5)	—
Beginning January 1, 1984	2.28 (7.8)	2.58 (8.8)	2.40 (8.2)[6]	2.69 (9.2)

1. Applies to equipment as listed for Table 6.1. All performances at sea level.
2. EER is Energy Efficiency Ratio, defined in Sec. 3; COP is defined in 6.3.3.
3. The Department of Energy has established required test procedures for single-phased, air-cooled residential central air-conditioners under 19 kW (65,000 Btu/h) in capacity, which have been incorporated into ARI Standard 210-79. EER (COP) values in Table 6.2 are based on Test A of the DOE Test Procedures.
4. Any minimum efficiency standard(s) promulgated by the Fedral Government may supersede minimum values, for the products to which they apply, established in this Table. See 2.3.
5. For Room Air-Conditioners, DOE will base its weighted average annual efficiency on EER determined in accordance with ANSI Z 234.1-1972.
6. Applies when return-air fans are not included under the manufacturer's model No. When return-air fans are included, the required minimum values are 2.34 (8.0).

BEST COPY AVAILABLE

Table 6.3.1
Applied HVAC System Components—Electrically Driven[1]
Standard Rating Conditions-Cooling[2]

Conditions			Centrifugal or Self-Contained Reciprocating Water-Chilling Package	Condenserless Reciprocating Water-Chilling Package	Hydronic System Water-Source Heat Pump
Leaving Chilled Water Temp.		°C (F)	6.7 (44)	6.7 (44)	—
Entering Chilled Water Temp.		°C (F)	12.2 (54)	12.2 (54)	—
Leaving Condenser Water Temp.		°C (F)	35.0 (95)	—	35.0 (95)
Entering Condenser Water Temp.		°C (F)	29.4 (85)	—	29.4 (85)
Air Temperature Entering Indoor Portion of Unit		°C (F)			26.7°C (80 F) DB 19.4°C (67 F) WB
Fouling Factor, Water[3]	Non-Ferrous Tubes		0.00009 (0.0005)[4]	0.00009 (0.0005)[4]	—
	Steel Tubes		0.00018 (0.0010)[4]	0.00018 (0.0010)[4]	—
Fouling Factor, Refrigerant			0.00000[4]	0.00000	—
Condenser Ambient	Air-or Evap.-Cooled	°C (F)	35.0 (95) DB 23.9 (75) WB	—	—
Compressor Saturated Discharge Temperature	Water-or Evap.-Cooled	°C (F)	—	40.6 (105)	—
	Air-Cooled	°C (F)	—	48.9 (120)	—
Refrigerant Liquid Temperature	Water-or Evap.-Cooled	°C (F)	—	35.0 (95)	—
	Air-Cooled	°C (F)	—	43.3 (110)	—
Air Temperature Surrounding Unit		°C (F)	—	—	26.7 (80)

1. Data in this Table 6.3.1 apply to the following types of HVAC System Components:
   Centrifugal or Rotary Water-Chilling Packages ARI Standard 550-77
   Reciprocating Water-Chilling Packages ANSI/ARI Standard 590-76
   Water-Source Heat Pumps ARI Standard 320-76 (For Hydronic Systems)
2. Standard Ratings are also based on other Standard Rating Conditions, such as, but not limited to, electrical conditions; indoor or condenser air quantities; minimum external flow resistances, etc., as provided in the applicable standards.
3. For Information on fouling factors, see the following standards:
   ARI Standard 450-74 for Water-Cooled Refrigerant Condensers, Remote Type
   ARI Standard 480-74 for Refrigerant-Cooled Liquid Coolers, Remote Type
   ARI Standards 550-77 and 590-76 also contain procedures for adjusting ratings for other than the Standard Rating fouling factor.
4. Fouling Factor Units: $m^2 \cdot K/W$ ($ft^2 \cdot h \cdot F/Btu$)

Table 6.3.2
Applied HVAC System Components—Electrically Driven[1]
Standard Rating Conditions—Cooling[2]

	Temperatures					
	(Evaporator)[2]		Condenser[3]			
			Air-Cooled[4]	Water-Cooled		Evaporatively-Cooled
			Air Entering	Water		Air Entering
Group No.	Saturation °C (F)	Return Gas °C (F)	(Dry Bulb) °C (F)	In °C (F)	Out °C (F)	(Wet Bulb) °C (F)
1	7.2 (45)	18.3 (65)	35 (95)	—	—	—
2	4.4 (40)	18.3 (65)	—	29.4 (85)	35 (95)	23.9 (75)

1. Data in this Table apply to HVAC Condensing Units. See ARI Standard 520-78 for Positive Displacement Refrigerant Compressors, Compressor Units and Condensing Units. Data are from Table 3 of ARI 520-78, Groups 1 and 2.
2. Not part of Condensing Unit; conditions to be maintained by separately furnished condenser.
3. Refrigerant liquid subcooling, in °C (F), shall be stated by the manufacturer as obtained under the conditions below as measured at the liquid line leaving the Condensing Unit.
4. With 35°C (95 F) dry bulb ambient air temperature surrounding unit.

71 BEST COPY AVAILABLE

Table 6.4
Applied HVAC System Components, Electrically Driven[1]
Minimum COP (EER)—Cooling[2]

		Water Chilling Packages				Hydronic Heat Pumps	
	Types	Condenser Included		Condenserless		Water Source	
Condenser Cooling Means		Air	Water	Air	Water	Under 19 kW (65,000 Btu/h)	19 kW (65,000 Btu/h) and Over
Beginning January 1, 1980	C	2.28 (7.8)[4]	3.98 (13.6)[4]	—	—	—	—
	R	2.20 (7.5)	3.40 (11.6)	2.78 (9.5)	3.40 (11.6)	—	—
Beginning January 1, 1984	C	2.34 (8.0)[4]	4.04 (13.8)[4]	—	—	2.64 (9.0)	2.75 (9.4)
	R	2.46 (8.4)	3.51 (12.0)	2.90 (9.9)	3.51 (12.0)	—	—

1. Applies to equipment as listed in Table 6.3.1. All performances at sea level.
2. Performance of Water-Chilling packages does not include energy to drive chilled-water and condenser-water pumps, or cooling-tower fans; for Hydronic Heat Pumps it does not include the energy to drive circulating water pump(s) and cooling-tower fan(s), but does include the conditioned supply-air fan-motor energy when included as part of the model number of the heat pump. The system designer shall determine the amount of the non-included energies and take them into account in determining the HVAC System COP (EER) and annual energy consumption.
3. C = Centrifugal or Rotary Type (ARI Standard 550-77)
   R = Reciprocating Type (ARI Standard 590-76).
4. Where double-bundle heat recovery is employed on centrifugal or screw compressor units, a lower EER is acceptable, provided that the gain by heat exchange exceeds the loss by lower EER; See 5.9.

Table 6.5
Applied HVAC System Components, Electrically Driven
Condensing Units 19 kW (65,000 Btu/h) and Over[1]
Minimum COP (EER)—Cooling[2]

	Positive Displacement		
Condensing Means	Air	Evaporative	Water
Beginning January 1, 1980	2.50 (8.5)	3.48 (11.9)	3.48 (11.9)
Beginning January 1, 1984	2.78 (9.5)	3.66 (12.5)	3.66 (12.5)

1. Per ARI Standard 520-78 for Positive Displacement Refrigerant Compressors, Compressor Units and Condensing Units.
2. Based on Standard Rating Capacity at Conditions in Table 6.3.2 and at sea level.

Table 6.6
HVAC System Cooling Equipment, Heat-Operated
Standard Rating Conditions—Cooling

		Heat Source	
Standard Rating Conditions		Direct Fired (Gas, Oil)	Indirect Fired (Steam, Hot Water)
Air Conditioners[1]	**Units**	**Temperatures**	**Temperatures**
Entering Conditioned Air	°C (F)	26.7 (80) DB; 19.4 (67) WB	—
Entering Condenser Air	°C (F)	35.0 (95) DB; 23.9 (75) WB	—
Water Chillers[2]			
Leaving Chilled Water	°C (F)	7.2 (45)	6.7 (44)
Fouling Factor	$m^2 \cdot K/W$ ($ft^2 \cdot h \cdot F/Btu$)		.00009 (.0005)
Entering Chilled Water	°C (F)	Per Mfgr. Spec.	12.2 (54)
Entering Condenser Water	°C (F)	23.9 (75)	29.4 (85)
Fouling Factor	$m^2 \cdot K/W$ ($ft^2 \cdot h \cdot F/Btu$)		.00018 (.0005)
Leaving Condenser Water	°C (F)	35.0 (95)	—
Condenser Water Flow Rate	litre/W · min (gpm/ton)	—	Per Mfgr. Spec.

[1] Per ANSI Standard Z21.40.1-1973 and Addenda for Gas-Fired Absorption Summer Air-Conditioning Appliances
[2] Per ARI Standard 560-75 for Absorption Water-Chilling Packages

BEST COPY AVAILABLE

Table 6.7
HVAC System Cooling Equipment, Heat-Operated[1]
Minimum COP[2]

Heat Source	
Direct Fired (Gas, Oil)	Indirect Fired (Steam, Hot Water)
0.48	0.68

[1] As listed in Table 6.6. At sea level.

[2] Minimum COP = $\frac{\text{Net Cooling Output}}{\text{Total Heat Input (Electrical Auxiliary Inputs Excluded)}}$

Table 6.8
HVAC System Heating Equipment—Gas- and Oil-Fired

	Minimum Steady-State Combustion Efficiencies		
	Residential/Commercial Boilers and Furnaces		Commercial/Industrial Boilers and Furnaces[2,3,4]
Types of Equipment	Residential[1]	Residential/Commercial[1,2]	Steady-State Combustion Efficiencies, Percent
Forced-Air Furnaces and Low-Pressure Steam or Hot-Water Boilers	74	74	75
Gravity Central Furnaces and other Vented Home Heating Equipment	69	—	—

Furnaces with Inputs less than 65.9 kW (225,000 Btu/h)

Boilers with Inputs less than 87.8 kW (300,000 Btu/h)

In accordance with DOE Test Procedures

Residential Furnaces with Inputs 65.9 kW (225,000 Btu/h) up to 117 kW (400,000 Btu/h)
Residential Boilers with Inputs 87.8 kW (300,000 Btu/h) up to 117 kW (400,000 Btu/h)
Commercial Boilers and Furnaces with Inputs up to 117 kW (400,000 Btu)

Commercial/Industrial Boilers and Furnaces with Inputs 117 kW (400,000 Btu/h) or more

[1] **Residential/Commercial Equipment Including Residential Equipment Covered Under DOE Requirements**

ARI 280-74 Central Forced Air Electric Heating Equipment
ANSI Z21.11.1-1977 (with Addenda 1979)—Gas-Fired Room Heaters, Vol.1—Vented Room Heaters
ANSI Z21.13-1977 (with Addenda 1979)—Gas-Fired Low-Pressure Steam and Hot Water Heating Boilers
ANSI Z21.44-1977 (with Addenda 1979)—Gas-Fired Gravity and Fan-Type Direct-Vent Wall Furnaces
ANSI Z21.47-1978—Gas-Fired Gravity and Forced-Air Central Furnaces
ANSI Z21.48-1979—Gas-Fired Gravity and Fan-Type Floor Furnaces
ANSI Z21.49-1979—Gas-Fired Gravity and Fan-Type Vented Wall Furnaces
ANSI Z91.1-1972—Performance Requirements for Oil-Powered Central Furnaces
ANSI/UL 727—Safety Standard for Oil-Fired Central Furnaces (October 1975)
ANSI/UL 729-1975—Safety Standard for Oil-Fired Floor Furnaces
ANSI/UL 730-1978—Safety Standard for Oil-Fired Wall Furnaces
UL896-1974—Safety Standard for Oil Fired Room Heaters
HI (January 1977)—Testing and Rating Cast-Iron and Steel Heating Boilers

[2] **Commercial/Industrial Equipment**

ABMA Packaged Firetube Boiler Ratings—1978
ABMA Packaged Commercial-Industrial Boiler Rating Criteria—1978
ASME PTC 4.1—ASME Power Test Code for Steam Generating Units—1976
ANSI Z21.34-1971—(with Addenda 1973,1974)—Gas-Fired Duct Furnaces
ANSI Z21.52-1971—(with Addenda 1973) Gas-Fired Single-Firebox Boilers
ANSI Z21.59-1974—Gas-Fired High-Pressure Steam and Hot Water Boilers (Inputs not over 400,000 Btu/h)
ANSI Z83.3-1971—(with Addenda 1972,1976)—Gas Utilization Equipment in Large Boilers
UL795-1975—Safety Standard for Gas-Fired Heating Equipment, Commercial-Industrial

In addition, ANSI Z21.13, ANSI Z21.47, ANSI Z91.1, ARI 280 and HI standards listed above are also applicable to commercial/industrial installations.

[3] See 6.6.1
[4] See 6.6.2

BEST COPY AVAILABLE

Table 6.9
HVAC System Heating Equipment (Heat Pumps), Electrically Operated[1]
Standard Rating Conditions[2]

Conditions	Type	Air Source		Water Source
Air Entering Equipment	°C (F)	21.1 DB (70 DB)	21.1 DB (70 DB)	21.1 DB (70 DB)
Outdoor Unit Ambient	°C (F)	8.3 DB/6.1 WB (47 DB/43 WB)	−8.3 DB/−9.4 WB (17 DB/15 WB)	— —
Entering Water Temperature	°C (F)	— —	— —	15.6 (70)
Water Flow Rate	—	—	—	As used in cooling mode[3]

[1]Data apply to following:
Air-Source Unitary Heat Pump Equipment-ARI Standard 240-77
Central Water-Source Heat Pumps-ARI Standard 320-76
Commercial and Industrial Heat Pump Equipment-ARI Standard 340-76
Packaged Terminal Heat Pumps-ARI Standard 380-78
[2]Additional Standard Rating Requirements are specified in the applicable standard
[3]See ARI Standards 320-76, 340-76

Table 6.10
HVAC System Heating Equipment and System Components, Electrically Driven (Heat Pumps)[1,2]
Minimum COP[3]

Heat Source Entering Temperature °C (F)	Air-Source 8.3 DB/6.1 WB (47 DB/43 WB)	Air-Source −8.3 DB/−9.4 WB (17 DB/15 WB)	Water-Source 15.6 (70)
Beginning January 1, 1980	2.5	1.5	2.5
Beginning January 1, 1984	2.7	1.8	3.0

[1]Equipment as listed in Table 6.9. All performances at sea level and exclude supplementary heat.
[2]"Equipment" here refers to central heat pumps, both air-source and water-source; "Components" refers to water-source heat pumps in hydronic systems.
[3]For both central and hydronic system water-source heat pumps, the COP values in the table do not include the power consumed by the water pump. In order to determine total system performance, it is the system designer's responsibility to take this power consumption into account. In addition, new (fossil fuel or electric) energy supplied to a boiler or other water heating device to restore the water-source temperature entering the heat pump shall be taken into account by the system designer. (See 6.7.3.1).
[4]Any minimum efficiency standard(s) promulgated by the Federal Government may supersede such minimum values established in this Table. See 2.3.

7.0 SERVICE WATER HEATING

7.1 Scope

7.1.1 The purpose of this section is to provide criteria for design and equipment selection that will produce energy savings when applied to service water heating.

7.1.2 It is not the intention of this section to develop either a procedure or method for designing a hot water distribution system, other than to offer criteria which, when applied, will reduce unnecessary uses of energy. For a more complete systems design guide, the reader should consult the 1976 ASHRAE HANDBOOK and Product Directory, Systems Volume, Chapter 37, Service Water Heating.[25]

Note: The Department of Energy is developing minimum efficiency standards or several classes of residential appliances in accordance with Public Law 95-619. If and when such standards become effective, they may preempt the recommended minima in this standard.

7.2 General. Hot water for domestic, sanitary and swimming pool purposes shall be generated and delivered in a manner conducive to saving energy.

7.3 Water Heaters, Storage Tanks, Boilers and Piping

7.3.1 Performance Efficiency

7.3.1.1 Electric Water Heaters

7.3.1.1.1 All automatic, electric, storage water heaters having a storage capacity of 450 liters (120 gallons) or less, and an input rating of 12 kW or less, shall have a standby loss not exceeding 43 W/m² (4 W/ft²) of tank surface area, or 43 W, whichever is greater, when tested in accordance with section 430.22e of the D.O.E. water heater test procedure published in the October 4, 1977 Federal Register, amended as to final rule in the September 7, 1979 Federal Register, and calculated at a 44.4°C (80 F) temperature difference.

7.3.1.1.2 All automatic, electric, storage water heaters having either a storage capacity greater than 450 litres (120 gallons) or an input rate greater than 12 kW

BEST COPY AVAILABLE

shall have all water backed storage tank surfaces insulated to an R value of at least 1.76m²·°C/W (10 ft²·h·F/Btu) or a standby loss not exceeding 43 W/m² (4 W/ft²) of tank surface area when tested in accordance with Section 4.3.1 of ANSI C 72.1-72 Household Automatic Electric Storage-Type Water Heaters.

7.3.1.2 Gas and Oil Fired Water Heaters

7.3.1.2.1 All gas and oil fired storage water heaters having an input rate of 22 kW (75,000 Btu/h) or less shall have a recovery efficiency (E_t) not less than 75 percent and a stand-by loss not exceeding

$$S = 2.3 + 250/V$$

where S is expressed in percent per hour of the stored thermal energy and where V = volume in litres (S = 2.3 + 67/V, where V = rated volume in gallons) when tested in accordance with section 430.22e of the D.O.E. water heater test procedure published in the October 4, 1977 Federal Register, amended as to final rule in the September 7, 1979 Federal Register.

7.3.1.2.2 All other gas fired water heaters shall have a thermal efficiency (E_t) of not less than 75 percent when tested in accordance with section 2.8 of ANSI Z21.10.3 - 1975.

7.3.1.2.3 All other oil fired water heaters shall have a combustion efficiency (E_c) of not less than 80 percent. Where combustion efficiency is 100 - flue loss, when measured at smoke = 0 (trace is permitted).

7.3.1.2.4 All gas and oil fired water heaters having an input rate over 22kW (75,000 Btu/h) but less than 0.3kW/litre (4,000 Btu/h per gallon) of self stored water shall also have a standby loss not exceeding

$$S = 2.8 + 25.9\,Q/V \quad (S = 2.8 + 0.002\,Q/V)$$

After January 1, 1982 the standby loss shall not exceed

$$S = 2.8 + 250/V \quad (S = 2.8 + 67/V)$$

Where V is the volume in litres and Q is the input in kW (where V = rated volume in gallons and Q = rated input in Btu/h).

7.3.1.2.5 All natural gas and oil fired water heaters having an input rate of more than 0.3 kW/litre (4,000 Btu/h per gallon) of stored water and having a pilot input rate greater than 0.5 percent of the maximum heater input rate (but not exceeding .22 W (750 Btu/h) shall be equipped with an ignition system which is not a continuously burning pilot light.

7.3.2 Combination Service Water Heating/Space Heating Boilers. Service water heating equipment shall not be dependent on year round operation of space heating boilers, that is, boilers that have as another function winter space heating, and vice-versa.

7.3.2.1 *Exception:* For systems where the use of a single heating unit will lead to energy savings then such a unit should be utilized.

7.3.2.2 *Exception:* Excepted from the provisions of 7.3.2 are systems with service/space heating boilers having a standby loss of W (Btu/h) less than

$$\frac{3.7 \times 10^4\ \text{pmd} + 117}{n} \quad \left(\frac{13.3\ \text{pmd} + 400}{n}\right)$$

where pmd is the probable maximum demand in m³/s (gallons/h) determined by the fixture count method as per Chapter 37 of the 1976 ASHRAE HANDBOOK and Product Directory, Systems Volume[23] and n is the fraction of the year when the outdoor daily mean temperature is greater than 18.3°C (64.9 F).

The standby loss is to be determined for a test period of 24 hour duration while maintaining a boiler water temperature of 32°C (90 F) above an ambient of 16°C (60 F) to 32°C (90 F) and a 1.5 m (5 ft) stack on appliance.

7.3.3 Insulation

7.3.3.1 Heat loss from unfired hot water storage tanks shall be limited to a maximum of 43 W/m² (13.6 Btu/h·ft²) of external tank surface area. The design ambient temperature shall be no higher than 18°C (65 F).

7.3.3.2 For recirculation systems, piping heat loss shall be limited to a maximum of 16.8 W per linear metre (17.5 Btu/h per linear ft) of pipe in accordance with Table 7.1 which is based on design external temperature no lower than 18°C (65 F). Other design temperatures must be calculated.

Exceptions: Piping insulation is not required when the heat loss of the piping, without insulation, does not increase the annual energy requirements of the building.

7.4 Temperature Controls. Service water heating systems shall be equipped with automatic temperature controls capable of adjustment from the lowest to the highest acceptable temperature settings for the intended use. (See Table 1 from ASHRAE 1976 HANDBOOK and Product Directory, Systems Volume, Chapter 37.[23])

7.5 Shut Down. A separate switch shall be provided to permit turning off the energy supplied to electric service water heating systems. A separate valve shall be provided to permit turning off the energy supplied to the main burner(s) of all other types of service water heating systems.

7.6 Pump Operation. Circulating hot water systems shall be arranged so that the circulating pump(s) can be conveniently turned off (automatically or manually) when the hot water system is not in operation.

7.7 Conservation of Hot Water

7.7.1 Showers used for other than safety reasons, shall limit the maximum hot water discharge to 0.19 litres/s (3 gpm) rated at pressure differences of 138 to 551 kPa (20 to 80 psi).

7.7.2 Lavatories in restrooms of public facilities shall:

a. Be equipped with outlet devices which limit the flow of hot water to a maximum of 0.032 litres/s (0.5

Table 7.1
Minimum Pipe Insulation

Service Water Heating Temperatures		Insulation Thickness for Pipe Sizes*							
		Non-circulating runouts Up to 1"		Circulating Mains & Runouts					
				Up to 1 1/4"		1 1/2"-2"		Over 2"	
°C	F	mm	In.	mm	In.	mm	In.	mm	In.
76.5-82	170-180	12.7	0.5	25.4	1.0	38.1	1.5	50.8	2.0
60-71	140-160	12.7	0.5	12.7	0.5	25.4	1.0	38.1	1.5
38-54	100-130	12.7	0.5	12.7	0.5	12.7	0.5	25.4	1.0

*Nominal iron pipe size and insulation thickness.
Conductivity K ~ 27

gpm) or, be equipped with self-closing valves that limit delivery to a maximum of 0.94 litres (0.25 gallons) of hot water for recirculating systems and to a maximum of 1.9 litres (0.50 gallons) for non-recirculating systems.

b. Be equipped with devices which limit the outlet temperature to a maximum of 43°C (110 F).

Exception: Separate lavatories for physically handicapped persons shall not be equipped with self-closing valves.

7.8 Swimming Pools

7.8.1 Pool Heaters

7.8.1.1 All pool heaters shall be equipped with an ON-OFF switch mounted for easy access to allow shutting off the operation of the heater without adjusting the thermostat setting and to allow restarting without relighting the pilot light.

7.8.1.2 After January 1, 1982, all gas and oil fired pool heaters shall have a thermal efficiency of 75 percent when tested in accordance with ANSI Z21.56-1975.

7.8.1.3 Active solar heating systems should be used to supply a portion of the pool heating requirements when conditions permit their cost effective installation.

7.8.2 Pool Covers. Heated swimming pools shall be equipped with a pool cover.

Exceptions: Outdoor pools deriving over 20 percent of the energy for heating from non-depletable sources (computed over an operating season.)

7.8.3 Time Clocks. Time clocks shall be installed so that the pump can be set to run in the off-peak electric demand period and can be set for the minimum time necessary to maintain the water in a clear and sanitary condition in keeping with applicable health standards.

7.9 Utilization of Waste Heat or Solar Energy

7.9.1 Consideration should be given to the use of condenser heat, waste energy, or solar energy to supplement hot water requirements when the first year's fuel cost savings resulting from the installation of such devices exceeds 20 percent of the initial additional cost.

7.9.2 Storage should be used to optimize heat recovery when the flow of heat to be recovered is out of phase with the demand for heated water.

BEST COPY AVAILABLE

APPENDIX C

Sections 10 and 11

ASHRAE Standard 90-75

ASHRAE/IES 90B-1975 (Sections 10 and 11 of ASHRAE/IES Standard 90-75)

The following Sections 10 and 11 (90B-1975) are identical to Sections 10 and 11 of Standard 90-75. They are included here for completeness and for the convenience of the user.

90B-1975 (designated for review 90.2-75R) is currently under revision and when and if the revision is approved it will supersede the Sections 10 and 11 in this document.

10.0 ENERGY REQUIREMENTS FOR BUILDING DESIGN ON SYSTEMS ANALYSIS

10.1 Scope

This section is included to provide an opportunity to deviate from the specific design criteria of Sections 4 through 9 by demonstrating that such deviations will result in annual energy consumption equal to or less than that resulting from compliance with these criteria.

10.1.1 Annual energy analyses are *not required* for buildings and alternative designs using various combinations of source energy which comply with Sections 4 through 9. Analysis criteria set forth in this section *may* be used to establish the annual energy requirements of each proposed design and in so doing will indicate the relative energy effectiveness of each design, thereby providing a basis on which the building owner and/or designer may select one system over another.

10.1.2 If any proposed design deviates from the specified design criteria of Sections 4 through 9, that design's annual energy consumption *shall* be compared to a similar building/system/energy source combination which does conform to Sections 4 through 9 (defined as a "standard design") to qualify it as an acceptable design. For instance, if electric heating and/or electric cooling are proposed for an alternate design which deviates from the criteria of Sections 4 through 9, then electric heating and/or electric cooling *shall* also be used in the comparative standard design to justify the deviation from the design criteria of Sections 4 through 9.

10.2 Equivalent Annual Energy Consumption

The standard design, conforming to the criteria of Sections 4 through 9, and the proposed alternative design *shall* be analyzed using the same procedures. The comparison *shall* be on a common basis. That is, it *shall* use equal floor area and equal environmental requirements. The comparison *shall* be expressed as Btu input per gross building square foot per year (MJ/m^2 per year).

10.2.1 Basis for Comparison. All forms of energy usage by both designs (standard and proposed alternate) covered under the provisions of Sections 4 through 9, *shall* be included in the comparison. Common climatic data, building occupancy, and building usage operational schedules *shall* be used in comparison. Where similar generic types of equipment and energy sources are applicable to the standard and proposed alternative design, such equipment and specific part load performance of such equipment along with related accessories *shall* be used in the comparison. In this type of comparison, identical energy forms *shall* serve the same purpose in both the standard and proposed alternative designs. (Electric cooling *shall* be compared to electric cooling, gas heating *shall* be compared to gas heating, etc.)

If the proposed alternative design results in an increase in consumption of one energy source and a decrease in another energy source (even though similar sources are used for similar purposes) the differences in each energy source *shall* be converted to equivalent energy units for purposes of comparing the total energy used.

10.3 Analysis Procedure

The analysis of the annual energy usage of the standard and the proposed alternative building and system designs *shall* meet the following criteria:

10.3.1 The building heating/cooling load calculation procedure used for annual energy consumption analysis *shall* be of sufficient detail to permit the evaluation of effect of building data (such as orientation, size, shape, transfer characteristics of mass, air, moisture, and heat) and hourly climatic data.

10.3.2 The calculation procedure used to simulate the operation of the building and its service systems through a full year operating period *shall* be of sufficient detail to permit the evaluation of the effect of system design, climatic factors, operational characteristics, and mechanical equipment on annual energy usage. Manufacturer's data or comparable field test data *shall* be used when available in the simulation of all systems and equipment. The calculation procedure *shall* be based upon 8760 hr of operation of the building and its service systems and *shall* utilize techniques recommended in the appropriate ASHRAE publications or produce results consistent with such recommended procedures.

10.3.2.1 The calculation procedure *shall* explicitly cover the following items:

a. Climatic data: coincident hourly data for temperatures, solar radiation, wind and humidity of typical days in the year representing seasonal variation
b. Building data: orientation, size, shape, mass, air, moisture and heat transfer characteristics
c. Operational characteristics: temperature, humidity, ventilation, illumination, control mode for occupied and non-occupied hours
d. Mechanical equipment: design capacity, part load profile
e. Internal heat generation, lighting, equipment, number of people during occupied and non-occupied periods

10.4 Documentation

Proposed alternative designs, submitted as requests for exception to the standard design criteria, *shall* be ac-

companied by an energy analysis comparison report prepared by a registered engineer. The report *shall* provide sufficient technical detail on the two building and systems designs and on the data used in and resulting from the comparative analysis to verify that both the analysis and the designs meet the criteria of 10.1 through 10.3.2.

10.4.1 The documentation *shall* demonstrate that the analysis used is consistent with the techniques and procedures specified by the following ASHRAE documents:

a. 1972 ASHRAE HANDBOOK OF FUNDAMENTALS[1]
b. 1973 ASHRAE HANDBOOK & Product Directory, Systems Volume[2]
c. *Energy Calculations I:* "Procedures for Determining Heating and Cooling Loads for Computerizing Energy Calculations – Algorithms for Building Heat Transfer Subroutines," 1975[3]
d. *Energy Calculations II:* "Procedures for Simulating the Performance of Components and Systems for Energy Calculations," 1975[4]

EXCEPTION. Proposed alternative designs for single-family, detached residential buildings and for light commercial structures having the indoor temperature controlled from a single point *may* be exempted from the full-year energy analysis as described in 10.3. A registered professional engineer *shall*, however, provide a comparison of energy consumption between the alternative design and the standard design. Simplified energy analysis, such as bin or Degree-Day methods, details of which can be found in Chapter 11[5] and 43[6] of the 1973 ASHRAE HANDBOOK & Product Directory, Systems Volume, may be used for this comparison.

References Used in Section 10

[1] ASHRAE HANDBOOK OF FUNDAMENTALS, ASHRAE, New York, NY, 1972.

[2] ASHRAE HANDBOOK & Product Directory, Systems Volume, ASHRAE, New York, NY, 1973.

[3] *Energy Calculations I:* "Procedure for Determining Heating and Cooling Loads for Computerizing Energy Calculations – Algorithms for Building Heat Transfer Subroutines," ASHRAE, New York, NY, 1975.

[4] *Energy Calculations II:* "Procedures for Simulating the Performance of Components and Systems for Energy Calculations," 3rd ed., ASHRAE, New York, NY, 1975.

[5] ASHRAE HANDBOOK & Product Directory, Systems Volume, Chapter 11, ASHRAE, New York, NY, 1973.

[6] ASHRAE HANDBOOK & Product Directory, Systems Volume, Chapter 43, ASHRAE, New York, NY, 1973.

11.0 REQUIREMENTS FOR BUILDINGS UTILIZING SOLAR, GEOTHERMAL, WIND OR OTHER NON-DEPLETING ENERGY SOURCES

11.1 General

When a proposed alternative building and service system design, submitted and evaluated in accordance with Section 10 of this Standard, utilizes solar, geothermal, wind or other non-depletable energy sources (see Section 3 – Definitions) for all or part of its energy sources, such non-depletable energy supplied to the building *shall* be excluded from the total energy chargeable to the proposed alternative design. To qualify for this exclusion, solar energy must be derived from a specific collection, storage and distribution system. The solar energy passing through windows *shall* also be considered as qualifying if such windows are provided with (1) operable insulating shutters or other devices which, when drawn or closed, *shall* cause the window area to reduce maximum outward heat flows to those in accordance with Fig. 1 and 3 of Section 4, and (2) the window areas are shaded or otherwise protected from the direct rays of the sun during periods when cooling is required.

11.1.1 This provision *shall* also apply to nocturnal cooling processes in lieu of energy-consuming refrigeration processes.

11.1.2 All other criteria covered in Section 10 *shall* apply to the proposed alternative designs utilizing non-depletable sources of energy.

11.2 Documentation

Proposed alternative designs, submitted as requests for exception to the standard design criteria, *shall* be accompanied by an energy analysis prepared by a registered engineer, as defined in Section 3. The report *shall* provide sufficient technical detail on the alternative building and system designs and on the data employed in and resulting from the comparative analyses as to verify that both the analyses and the designs meet the criteria of 10.2 and 10.3 and this section. The energy derived from non-depletable sources and the reduction in conventional energy requirements derived from nocturnal cooling, *shall* be separately identified from the

BEST COPY AVAILABLE

overall building energy use. Supporting documentation, on the basis of the performance estimates for the aforementioned non-depletable energy sources or nocturnal cooling means, must be submitted.

EXCEPTIONS. Proposed alternative designs for residential and light commercial structures of less than 20,000 ft^3 (1860 m^3) that derive a significant portion of their total annual energy usage from non-depletable sources or from nocturnal cooling, *shall* be exempt from the requirement of a full-year energy system analysis, providing that a registered engineer concurs in writing that the average annual input of such non-depletable sources, or the extent of such nocturnal cooling can reasonably be expected to meet the demands imposed by the proposed alternative design. Other commercial, institutional and industrial structures that derive over 50 percent of their annual thermal requirements (heating, cooling, service water heating) or over 30 percent of their annual total energy requirements from non-depletable sources *shall* be exempted from the necessity of comparing the proposed design to a standard design which follows the provisions of Sections 4 through 9. Documentation, provided by a registered engineer, verifying the percentage of annual energy use derived from such non-depletable sources *shall* be required as provided in 11.2.

BEST COPY AVAILAB